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BUFFALO SOCIETY OF NATURAL SCIENCES

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Guide to the Geology and Paleontology of Niagara Falls and Vicinity

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ALBANY
University of the State of New York
1901

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PREFACE

With the support and cooperation of the Buffalo society of natural sciences and the department of paleontology of the state museum, Dr Grabau has prepared this guide to the geology and paleontology of Niagara falls and vicinity with the special purpose of affording to visitors to Buffalo during the season of the Pan-American exposition in 1901 a viaticum in their tours through this region renowned for its scenic features and classic in its geology. The ground has been the subject of a multitude of scientific treatises concerned now with the succession of events in the upbuilding of the rock strata along the canyon of the river; again with the nature of the organic remains inclosed in these strata; sometimes with the changes which the falls have undergone in historic times, but for the most part with the perplexing problems of the origin of the present drainage over the great escarpment and through the gorge, the raison d'être of the falls, the various changes in the course and work of the Niagara river since its birth and the significance of the present topography of the region. These scientific investigations began with the careful surveys instituted by the late Prof. James Hall, state geologist and paleontologist, during the years of his explorations in the 4th geologic district of this state from 1837-43, who, in addition to his record of the work done by this tremendous agent, derived from this region an important term in the New York series of rock formations, the Niagara group, and portrayed the organisms of the various strata which are so superbly exposed along its great channel. Lyell and Bigsby, Logan, Gilbert, Upham, Spencer, Leverett and Taylor are among the names of others who have contributed, from various points of view, facts and hypotheses relating to the geologic history of the river. In no one place however has the general purport of all these various studies been brought together so that the intelligent traveler or student can acquire them in convenient form. It is for this reason that Dr Grabau's work in bringing together in concise form the essence of these investigations, tempered and proved by his own review of them in the field, will not fail to prove serviceable to a large element of the public.

JOHN M. CLARKE

State paleontologist

Plate 1

Niagara falls from Father Hennepin's view point

INTRODUCTION —NIAGARA FALLS AND HOW TO SEE THEM[1]

The falls of Niagara have been known to the world for more than 200 years. Who the first white man was that saw the great cataracts is not known, but the first to leave a description was the French missionary, Father Louis Hennepin, who, in company with La Salle, visited the falls in 1678. He was the first white man to use the name, Niagara, for the river and the falls, a name which had been applied by the Neuter Indians, who occupied the territory on both sides of the river prior to the year 1651, when they were conquered by the Senecas, who after that occupied and possessed the territory.[2] In the native language the name is said to signify "the thunder of the waters".

The first sight of the great cataracts must have made a powerful impression on Father Hennepin, unprepared as he was by previous descriptions save those given him by his Indian allies and guides. He speaks of the falls as "a vast and prodigious Cadence of Water which falls down after a surprizing and astonishing manner, insomuch that the Universe does not afford its Parallel".[3] He considered the falls "above Six hundred foot high", and adds that "the Waters which fall from this horrible Precipice, do foam and boyl after the most hideous manner imaginable, making an outrageous Noise, more terrible than that of Thunder, for when the

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[1] Niagara falls are reached from Buffalo by train or electric cars, both of which run at frequent intervals. A direct line of railway runs from Rochester to the falls by way of Lockport. Direct railway connection with western cities is obtained by way of Suspension bridge, while from Toronto and other cities north of Lake Ontario the falls may be reached by train direct, or by boat to Lewiston or Queenston, and thence by train or electric road to Niagara. All electric cars on the New York side run to or past Prospect park, and most of them pass the railway stations. The railway stations are within walking distance of the falls.

[2] Porter, Peter A. Goat island. 16th an. rep't comr's state reservation, 1900.

[3] A new discovery of a vast country in America. 1698. p. 29. Reprinted in part in special report N. Y. state survey for 1879.

Wind blows out of the South, their dismal roaring may be heard more than Fifteen Leagues off."[1]

If today, from our vantage ground of precise knowledge, we smile on the extravagant estimates of Father Hennepin, it may be asked, who among us, that is capable of admiration and enthusiasm at the sight of nature's grand spectacles, would, on coming unprepared on these great cataracts, be able to form a calm and just estimate of hight and breadth and volume of sound?

Since the time of La Salle and Hennepin, the falls have been viewed by a constantly increasing number of visitors. For Americans of the present generation and for people of other lands as well, Niagara has become a sort of Mecca, to which they hope once in their life time to journey. With many this is a hope long deferred in realization, with most perhaps it is a dream never realized, but those who do go and see, come away with their conceptions of nature much enlarged and with memories which cling to the end of life. Fully to appreciate Niagara, one must give it more than a passing glance from the carriage of an impatient driver, who is anxious to have you " do " Niagara in as short time as possible, that he may secure another " fare ". Learn to linger at Niagara, and give nature time to impress you with her beauty and her majesty. " Time and close acquaintanceship," says Tyndall, " the gradual interweaving of mind and nature, must powerfully influence any final estimate of the scene ". And the growing impression which this incomparable scene produced on him, served to strengthen the desire " to see and know Niagara falls as far as it is possible for them to be seen and known".[2]

It is surprising that many of the visitors to the falls allow themselves to be hurried past some of its most beautiful spots and to bestow on others only casual attention, and then waste a wholly disproportionate amount of time in the museums and curio stores looking for souvenirs purporting to come from Niagara but generally manufactured elsewhere. Real and valuable Niagara souvenirs may be had for the trouble of picking them up, in the minerals, fossils and shells which abound in the vicinity of the falls.

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[1] *Loc. cit.*

[2] Tyndall. Fragments of science, " Niagara ".

And, while one gathers these, one's knowledge of Niagara becomes broadened, and the perception grows that there are other lessons to be learned in this region, lessons of even more tremendous import than those taught by the cataracts.

The pedestrian has by far the best opportunity to see and enjoy nature as she is only to be seen and enjoyed at Niagara. The stately forest beauty of Goat island, unequaled in the estimation of those competent to judge, by that of any other wooded spot of similar size; the constantly changing views of gorge and falls and rapids which are obtained from nearly every path on the islands and the mainland on both sides of the river; the magnificence of the turbulent waters as they rush toward you, wave piling on wave, till it seems as if the frail-looking structure on which you stand must inevitably be carried away by them—none can enjoy these to their full extent while sitting in a carriage, though it move never so slowly, or while being compelled to listen to the descriptions and explanations of an unsympathetic and unappreciative driver. If you must ride, patronize the reservation carriages, which leave you wherever you wish to stop and take you on again at your own pleasure.[1]

Views from the New York side

The first view of the falls which the visitor on the New York side enjoys is generally from Prospect point, or some of the more elevated view points along the brink of the gorge in Prospect park (*see* frontispiece, pl. 1). While impressive, this view by no means reveals to its full extent the matchless grandeur of the cataracts, and in this respect the visitor on the Canadian side has the advantage. However, the views from Prospect point and Father Hennepin's view point should be obtained by every one, and it may be that some will find greater attraction in these than in the more comprehensive views obtained from the other side. While in Prospect park, it is well to descend to the foot of the inclined railway, and get the views of the falls from below. The ride on the *Maid of the Mist* will be found an interesting and novel experience, besides affording views of the cataracts obtainable in no other way; but most people will defer this till they have seen more of the cataracts and rapids from above. In visiting the foot of the falls, an umbrella should be taken, while a waterproof cloak will be found of great advantage, for the visitor is apt to be drenched by the spray which will be blown on him unawares. Caution is necessary here, as everywhere at Niagara, to avoid accidents. In the talus heaps of limestone fragments, minerals and occasionally fossils may be found.

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[1] These carriages are run at intervals of 15 minutes, starting from Prospect park, and making the circuit of Goat island. The fare is 15c for the round trip, and stop-overs at all places, and for any length of time on the same day, are allowed.

From Prospect point the visitor should next turn his attention to Goat island, " the most interesting spot in all America ", as Capt. Basil Hall called it. The unpoetic name of this island is, as Mr Porter tells us[1], commemorative of the power of endurance of a male goat, which, in company with a number of other animals, had been left on this island uncared for during the severe winter of 1770-71, and proved the only survivor.

From the bridges which cross to Green, and thence to Goat island, memorable views of the rapids above the falls may be obtained; and the visitor will do well to pause, that he may become impressed by the magnificence of the spectacle. Perhaps he will feel as did Margaret Fuller, who said: " This was the climax of the effect which the falls produced upon me—neither the American nor British fall moved me as did these rapids." The naturalist will be interested to note that, in spite of the fearful rush of water, freshwater mussels have found a lodging place among the more protected rocks, where they seem to thrive well. Along the shores of the islands, in places where other animals would find it hard to gain a foothold, numerous small gastropods may be found clinging to the slippery rock surfaces.

On Goat island, despite the so-called " improvements " for the convenience of visitors, nature still reigns supreme. The virgin character of the forest is almost undisturbed, as it was when the red man regarded this as the sacred abode of the Great Spirit of

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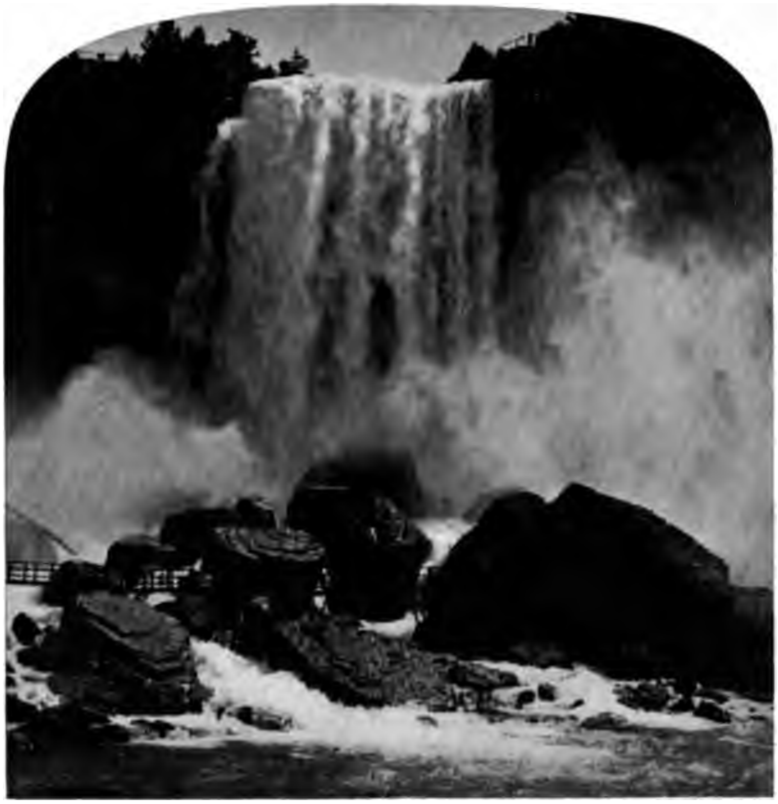
[1] Porter. Goat island.

Plate 2



Luna falls, and the limestone fragments at its base (Copyright by Underwood & Underwood, New York)

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Niagara. The botanist will here find a greater variety of plants within a given space than in almost any other district.[1]

But it is in the wonderful views of the falls and the rapids and the gorge which can be obtained from this island, that its chief attraction lies. The various view points are easily found, and the stroller about Goat island would best come on them unawares. Mention may be made of the glimpses of the American falls obtained from the head of the stairway leading to Luna island, as well as from the island itself, and the panorama of rapids, falls and gorge from the Terrapin rocks at the edge of the Horseshoe falls. Every visitor is advised to descend the Biddle stairway and view the falls from below. No charge is made unless one wishes to enter the Cave of the winds, a most thrilling experience for a person of nerve and one unparalleled by any other which may legitimately be obtained at Niagara. But, even if one does not care to go behind the falls, a visit to the foot of the stairway, and a walk along the path at the base of the vertical cliff of limestone will well repay the exertion of the climb. Many noble views of the gorge and the falls may be obtained from the stairway, while from certain points below, impressive sights of the small central fall are to be had. Here too can be seen the undermining action of the spray, which removes the soft shale, leaving the limestone ledges projecting till in the course of time they fall for want of support. On the talus slopes at the foot of the cliff good specimens of minerals and occasional fossils may generally be obtained.

After leaving the Biddle stairway, and the Terrapin rocks, the visitor will proceed southward along the river bank to the bridge leading to the Three Sister islands. On the way the geologist will pause where a wood-road leads off to the left into the famous gravel pit of Goat island, since there the shell-bearing gravels are exposed.[2]

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[1] A catalogue of the flowering and fern-like plants growing without cultivation in the vicinity of the falls of Niagara, by David F. Day, is published in the 14th annual report of the commissioners of the state reservation. In this a total of 909 species are recorded, a large proportion of which are credited to Goat island.

[2] These shells are described in chapter 5.

A small fall known as "The Hermit's cascade" lies between Goat island and the First Sister. In the pool at the foot of this fall Francis Abbot, the Hermit of Niagara, was wont to take his daily bath.

From the bridges and from the islands unsurpassed views of the upper rapids are obtained. These are particularly impressive when seen from the rocks of the Third Sister. Of these rapids as seen from the Terrapin rocks, the Duke of Argyle wrote:

> When we stand at any point near the edge of the falls, and look up the course of the stream, the foaming waters of the rapids constitute the sky line. No indication of land is visible—nothing to express the fact that we are looking at a river. The crests of the breakers, the leaping and the rushing of the waters, are still seen against the clouds as they are seen in the ocean, when the ship from which we look is in the trough of the sea. It is impossible to resist the effect of the imagination. It is as if the fountains of the great deep were being broken up, and that a new deluge were coming on the world. The impression is rather increased than diminished by the perspective of the low wooded banks on either shore, running down to a vanishing point and seeming to be lost in the advancing waters. An apparently shoreless sea tumbling toward one is a very grand and a very awful sight. Forgetting, then, what one knows, and giving oneself to what one only sees, I do not know that there is anything in nature more majestic than the view of the rapids above the falls of the Niagara.

On returning to Goat island the visitor may take the reservation carriage for a return to Prospect park, or he may continue his walks around or across Goat island.

In front of Prospect park the electric cars may be taken to cross the river, the bridge-toll which every foot passenger has to pay, being included in the car fare.

Views from the Canadian side

The Canadian side is reached either by bridge or by the steamer *Maid of the Mist*.[1] Every visitor to the falls should obtain the views from the Canadian side, which are in many respects superior to any obtainable on the New York side. Several rustic arbors have been constructed along the brink of the gorge in Queen Victoria park, and here the visitor may tarry for hours and not weary of the sights he beholds. The remarkable vivid green of the water of the Horseshoe falls will excite the observer's interest, and question. Tyndall observes that, while the water of the falls as a whole "bends solidly over and falls in a continuous layer. . . close to the ledge over which the water rolls, foam is generated, the light falling upon which, and flashing back from it, is sifted in its passage to and fro, and changed from white to emerald-green."[1]

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[1] If the visitor plans to take the belt line ride—Niagara, Queenston, Lewiston—he will have opportunity to stop off in Queen Victoria park, and need not make a special crossing.

Near the edge of the Horseshoe falls are the remains of Table rock, formerly a projecting limestone shelf of considerable extent, and a favorite view point. Huge portions of this rock have fallen into the gorge at various times, the most extensive falls occurring in 1818 and 1850, with minor ones between and since. On one occasion some forty or fifty persons had barely left the rock before it fell. From the remaining portion of this rocky platform a good near view of the Horseshoe falls is obtained, though the visitor is apt to find himself in a drenching shower of spray at almost all times.

Beyond Table rock, in the upper end of the park, and on the Dufferin islands many attractive walks are to be met with. These are generally little visited and afford an opportunity for solitude and escape from the crowds of sightseers. Some of the best views of the rapids above the falls are to be obtained here. A wooded clay cliff bounds the park on the landward side, generally rising steeply to the upland plateau. Here on July 25, 1814, the memorable battle of Lundy's Lane was fought between the British and the Americans; "within sight of the falls, in the glory of the light of a full moon, the opposing armies engaged in hand-to-hand conflict, from sundown to midnight, when both sides, exhausted by their efforts, withdrew from the field".[2]

At the head of the park, a road leads to the upland, where is situated the famous burning spring. The inflammable gas which here bubbles through the water of the spring is chiefly sulfureted hydrogen, but the quantity is such as to produce a flame of considerable magnitude, and it is asserted that the supply has not diminished for the hundred years or more that the spring has been known to exist.[3]

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[1] *Loc. cit.*

[2] Porter.

[3] An admission fee is charged here.

The gorge below the falls

. The gorge of the Niagara river should be seen from both sides. Here as elsewhere the pedestrian with abundant time has the best opportunity to see the numerous interesting and attractive features; but, since distances here are considerable, it is perhaps more advisable to avail one's self of the conveyances afforded.[1]

The best view of the gorge is afforded by going down the river on the Canadian side and returning by the gorge road. In this way the passenger on the cars gets nearest to the river, particularly if the right hand seats are selected. If the visitor however prefers to go down the river on the gorge road, and return by the Canadian line, let him choose the left side of the cars as nearest to the river in both cases.

After passing Clifton on the Canadian side, and the last of the bridges which here span the gorge, the observer begins to have a view of the whirlpool rapids, which even from this elevation have a threatening aspect. It was through these rapids and through the whirlpool below, that the first *Maid of the Mist* was safely navigated in 1861, having at the time three men on board—a feat which has never been repeated. Through this same stretch of rapids Capt. Webb made his fatal swim,paying for the foolhardy attempt with his life. After passing the rapids we reach the whirlpool, of which good views are afforded from many places along the top of the bank. After crossing several small ravines, that of Bowmans creek is reached. This ravine is a partial reexcavation of the old drift that filled St Davids channel.[2] From the upper end of the bridge which crosses the ravine, a path leads down to the water's edge, the ravine being one of singular attractiveness to the lover of wild woodland scenery. A short distance beyond the bridge is the Whirlpool station of the electric road. Here, from a little shelter built on the extreme point, fine views of the whirlpool and the river above and below it are obtained. The river here makes a right-angled bend, the whirlpool forming the swollen elbow. In the rocky point projecting from the bank on the New York side the succession of strata is finely shown[1]; and from this point northward the New York bank exposes a nearly continuous section as far as the mouth of the gorge at Lewiston.

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[1] The visitor will do well to purchase a belt line ticket, which entitles him to make the circuit in either direction and to stop at all important points. The Canadian scenic route will take him along the top of the bank, while the gorge road, on the New York side, takes him close to the edge of the water.

[2] *See* map, and chapter 1.

A short distance below the whirlpool we reach Foster's flats, or Niagara glen, as it is more appropriately called. This is visited by comparatively few tourists, though it is one of the most attractive spots along the gorge.[2] It marks the site of a former fall, and, besides its interest on that account deserves to be visited for its silvan beauty and its wild and picturesque scenery of frowning cliff, huge moss-covered boulders and dark cool dells, where rare flowers and ferns are among the attractions which delight the naturalist. Many good views of the river and the opposite banks may here be obtained, and the student of geology will find no end to instructive features eloquent of the time when the falling waters were dashed into spray on the boulders among which he now wanders. After leaving Niagara glen the visitor should stop at Queenston hights and obtain the view which is here afforded.[3] If possible the more comprehensive views from the summit of Brock's monument should be obtained.[4]

After descending and crossing to the New York side, one may return directly by the gorge road, leaving the inspection of the fossiliferous strata for another day, or one may, after a rest at the hotel, or on the river bank, spend some hours in studying the sections exposed along the New York Central railroad cut.[5]

The return journey by the gorge road is one of great interest, as it carries the visitor close to the rushing waters of the river. Walking along the roadbed is forbidden, and stops are made only at the regular stations.[6] The first of these is the Devil's hole, a cavern in the rock, of the type described in chapter 3 and supposed to have figured in Indian lore. The ravine of Bloody run, a small stream generally dry during the summer season, was the scene of a fearful massacre of the English soldiers by the Seneca Indians in 1763, the whole party with the exception of two, with wagons and horses, being driven over the cliff by the savages, and dashed to pieces on the rocks below. Next above the Devil's hole is Ongiara[1] park, a picturesque wooded slope opposite the southern end of Foster's flats, and like parts of that region are dotted with enormous blocks of limestone, which have fallen from the bank above. A short distance above this we come to the whirlpool, where a stop of some time can profitably be made. But by far the most attractive place at which to stop is the whirlpool rapids. The water which here rushes through a narrow and comparatively shallow channel, makes a descent of nearly 50 feet in the space of less than a mile, and its turbulence and magnificence are indescribable. Seen at night by moonlight, or when illuminated by the light from a strong reflector, the spectacle is beyond portrayal. We may perhaps not inaptly apply Schiller's description of the Charybdis to these waters:

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[1] For a description of these, *see* chapter 3.

[2] *See* chapter 2.

[3] *See* chapter 1.

[4] An admission fee is charged here.

[5] Waggoner's hotel near the Lewiston suspension bridge makes a convenient stopping place, specially if one desires to visit the fossiliferous sections. The Cornell, at the ferry landing, opposite the Lewiston railroad station, is also recommended.

[6] In stopping off, be sure to obtain stop-over checks from the conductor.

Und es wallet und siedet und brauset und zischt,
Wie wenn Wasser mit Feur sich mengt.
Bis zum Himmel spritzet der dampfende Gischt,
Und Well' auf Well' sich ohn' Ende drängt,
Und wie mit des fernen Donner's Getose,
Entstürzt es brüllend dem finstern Schosse.

Fossiliferous sections

These sections are to be seen on the cut of the New York Central and Hudson river railroad, Lewiston branch, and along cuts of the Rome, Watertown and Ogdensburg railroad at Lewiston hights. The former are approachable from Lewiston on the north or the Devil's hole station on the south. The approach from Lewiston is the more natural, as it will give the strata in ascending order. Waggoner's hotel makes a convenient starting point. Follow the car tracks southward to where a road leads off on the left. Entering this, a wood-road is found to lead off on the right, which when followed will bring you on the terrace formed by the quartzose sandstone bed, and on which the bridge towers stand. A quarry in the white sandstone by the roadside gives an opportunity to study this rock, which is practically barren of fossils. Beyond this the tracks of the New York Central railroad are reached, which, after traversing a short tunnel hewn out of the Medina sandstone, bring you to the sections in the gorge (plate 12). Care must be exercised in exploring these sections, as trains are frequent, and rockfalls from the cliffs are among the daily occurrences. With a little caution however the sections may be studied without danger. The total amount of walking necessary from Waggoner's hotel to the Devil's hole is about 3 miles. Near the upper end of the section, where the track enters a rock cutting, a steep path along the river bank leads to the top of the rocky plateau, and a short walk along the top of the bank will bring you to the Devil's hole station. One may also climb the bank in the quarry at the head of the section, and, passing along the top, reach the Devil's hole station by crossing the bridge over the rock-cut before mentioned. At the Devil's hole station[1] one may either take the surface car, which runs to Niagara falls at frequent intervals (5c fare), or, by paying the admission to the Devil's hole, descend to the gorge road and continue the journey to the falls. (A ticket or 50c fare is required here.)

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[1] One of the 40 ways of spelling Niagara.

If the sections are approached from the upper end, the Devil's hole station may be reached by the surface electrics[2] or the visitor may leave the cars of the gorge road at the lower Devil's hole station, and, paying the admission fee, ascend the banks by the stairs and paths. The path from the Devil's hole station to the sections leads close along the brink of the gorge. If the sections are visited in the forenoon, the investigator will find himself in the shadow of the cliffs, which is most grateful on a warm summer day.

The sections on the Rome, Watertown and Ogdensburg railroad are reached from Waggoner's hotel by paths leading up " the mountain " one of which begins on the New York Central tracks not far north of the tunnel.

Geologic nomenclature

Geologic time is divided into five great divisions, based on the progress of life during the continuance of each. These are:

5 Cenozoic time, or time of " modern life "
4 Mesozoic time, or time of " medieval life "
3 Paleozoic time, or time of " ancient life "
2 Proterozoic time, or time of " first life "
1 Azoic time, or time of " no life "

---

[1] Refreshments may be obtained here.

[2] These electrics run from near Prospect park to the Devil's hole and return, at short intervals.

Each of these time divisions is farther divided into great eras, those of Paleozoic time being given in the annexed table. Each era is in general divisible into three periods of time, the early, middle, and later, for which the prefixes *paleo* (or *eo*), *meso* and *neo* are used. The farther division of the periods is into epochs.

During the continuance of each great time division of the geologic history of the earth, more or less extensive rock systems were deposited, wherever the conditions were favorable. Thus the Paleozoic rock system is that deposited during Paleozoic time. That part of the Paleozoic rock system which was deposited during the Siluric era, is called the Siluric rock series, and similarly, the name of each of the other great *eras* is also applied to the rock series deposited during its continuance. In like manner each geologic *period* has its corresponding *group* of rocks deposited during its continuance. These rock groups and their farther subdivision into stages have, in New York, received local names, the name of the locality where the rocks are best developed being selected. The rocks formed during Proterozoic and Azoic time are generally spoken of as pre-Cambric.

The following table embodies the result of the latest studies.[1] The thicknesses are chiefly obtained from well records published by Prof. I. P. Bishop. The relations of these strata to each other in this region are shown in the north and south section from Canada to the New York-Pennsylvania line, presented in fig. 1.

Ever since the days of Lyell and Hall the life history of Niagara and the origin of the Great lakes has engaged the attention of geologists the world over. Among the names prominent in connection with studies of the geology of Niagara in one or more of its aspects, may be mentioned those of Bishop, Clarke, Claypole, Davis, Fairchild, Gilbert, Hall, Hitchcock, Lesley, Lyell, Newberry, Pohlman, Ringueberg, Shaler, Spencer, Tarr, Taylor, Upham and Wright, besides a host of others.[2]

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[1] Clarke and Schuchert. Science. n. s. Dec. 15, 1899, 10:3. It will be found to differ in some respects from the table published in the author's Geology of Eighteen Mile creek, etc.

[2] In the field work I have had the efficient assistance of my friend Mr R. F. Morgan of Buffalo.

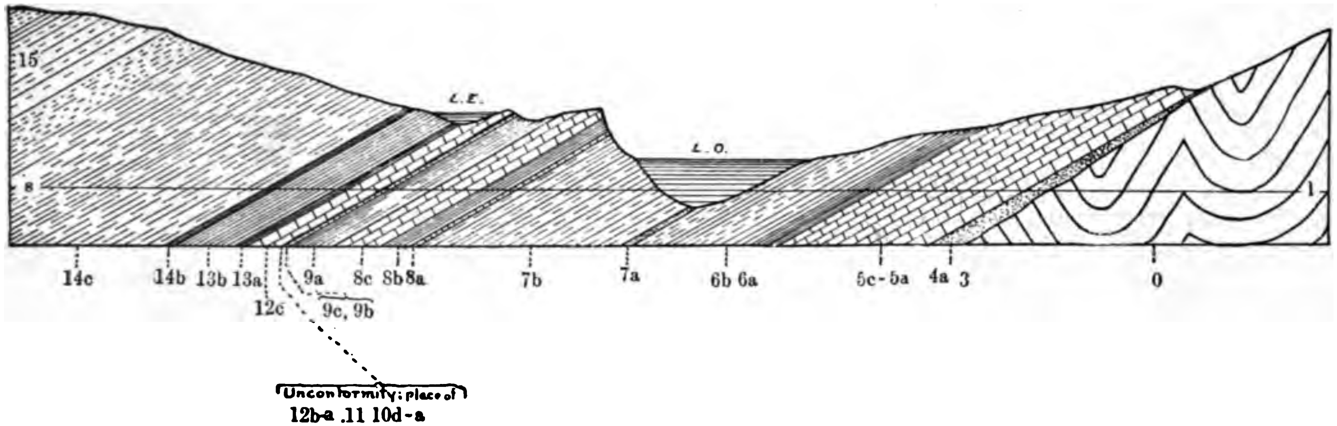

Fig. 1 Section from the Canadian highlands across western New York to the Pennsylvania line, showing the succession of strata. The numbering of the beds corresponds to that of the succeeding table. Owing to the great exaggeration of the vertical over the horizontal scale, the dip of the strata appears much too steep. s. l. = sea-level, L. E. = Lake Erie, L. O. = Lake Ontario. Horizontal scale 1 inch = 38 miles. Vertical scale, 1 inch = 1500 feet.

Table of Paleozoic subdivisions

Time scale	Formation scale	New York state rock equivalents	Thickness in the Niagara region
Paleozoic time	*Paleozoic system*		
5 Carbonic era	5 Carbonic series		
c Neocarbonic period	*c* Upper Carbonic group	Absent in New York	
b Mesocarbonic period	*b* Middle Carbonic group	"	
a Paleocarbonic period	*a* Lower Carbonic group	"	
4 Devonic era	4 Devonic series		
c Neodevonic period	*c* Upper Devonic group	*c* Upper Devonic group	
		15 Chautauquan subgroup	?
		15a Chemung beds (Catskill sandstone, local facies)	
		14 Senecan subgroup	
		14c Portage beds	
		3) Oneonta beds 2) Ithaca beds 1) Naples beds (local facies)	938' to 1541'
		14b Genesee shale	17' to 25'
		14a Tully limestone	absent
b Mesodevonic period	*b* Middle Devonic group	*b* Middle Devonic group	
		13 Erian subgroup	
		13b Hamilton beds	76'
		13a Marcellus shale	211'
		12 Ulsterian subgroup	
		12c Onondaga limestone (including Corniferous)	108' to 250' ?
		12b Schoharie grit	absent
		12a Esopus grit	absent
a Paleodevonic period	*a* Lower Devonic group	*a* Lower Devonic group	
		11 Oriskanian subgroup	
		11a Oriskany beds	thin streaks of sandstone
		10 Helderbergian subgroup	
		10d Kingston beds (upper shaly)	absent
		10c Becraft limestone (upper Pentamerus)	absent

3 Siluric era *c* Neosiluric period	3 Siluric series *c* Upper Siluric group	10b New Scotland beds (Delthyris shaly)	absent
		10a Coeymans limestone (Lower Pentamerus)	absent
		9 Cayugan group	
		9c Manlius limestone	7′ to 8′
		9b Rondout waterlime	60′
		9a Salina beds	386′
b Mesosiluric period	*b* Middle Siluric group	8 Niagaran group	
		8d Guelph dolomite	absent?
		8c Lockport limestone (Niagara limestone)	200′ to 247′
		8b Rochester shale (Niagara shale)	70′ to 80′
		8a Clinton beds	23′ to 40′
a Paleosiluric period	*a* Lower Siluric group	7 Oswegan group	
		7b Medina sandstone	1266′±
		7a Oswego sandstone, Oneida conglomerate or Shawangunk grit	75′±
2 Ordovicic era *c* Neordovicic period	2 Ordovicic series *c* Upper Ordovicic group	6 Cincinnatian group	
		6c [Richmond beds] absent	
		6b Lorraine beds 6a Utica shale	630′
b Mesordovicic period	*b* Middle Ordovicic group	5 Mohawkian group	
		5c Trenton limestone 5b Black river limestone	680′ to 720′
		5a Lowville limestone (=Birdseye limestone)	absent?
a Paleordovicic period	*a* Lower Ordovicic group	4 Canadian group	
		4b Chazy limestone	absent?
		4a Beekmantown limestone (=Calciferous sandstone)	10′ to 110′
1 Cambric era *c* Neocambric period	1 Cambric series *c* Upper Cambric group	3 Potsdamian group	
		3a Potsdam sandstone and limestone	
b Mesocambric period	*b* Middle Cambric group	2 [Acadian]	absent
a Paleocambric period	*a* Lower Cambric group	1 Georgian group	absent
		1a Shales and limestones of Troy and Washington co. N. Y.	

Geologic map

A few words, descriptive of the accompanying geologic map may be added.

The topography is indicated chiefly by contour lines. These lines are 20 feet apart, and each connects the points which have the same elevation above sealevel. Thus wherever the 300 foot contour line occurs, every point along that line is supposed to be 300 feet above sealevel. The level of Lake Ontario is 247 feet above the sea; therefore the hight of any point above Lake Ontario can be calculated from the contours. Where the contours are close together, the slope of the country is steep; where far apart, it is gentle.

The various color patterns indicate what geologic formations would be shown on the surface of any given area, if the drift covering were removed. The beds of this region all dip gently southward; and, as we proceed northward, the lower beds rise from beneath the covering of the higher. Where steep cliffs occur, as in the gorge of the river or at Lewiston or Queenston, the lower beds crop out beneath the upper ones for only a very short space; hence they appear on the map as narrow color bands only. The character of the outcrops in the buried St Davids channel is only approximately delineated, to the extent indicated by well borings. It is probably much more irregular than is shown.

The outlines of the edges of the various beds from Lewiston eastward are taken from a map by G. K. Gilbert, the man who more than any other is identified with geologic studies at Niagara. The outcrops of the Onondaga and waterlime beds are taken from a map by Prof. I. P. Bishop. For the other outlines the author is responsible.

A few statistics[1]

Hight of American falls, Oct. 4, 1842	167.7	feet
" Horseshoe falls, "	[2]158.5	"
Mean total recession of American falls between 1842 and 1890	30.75	"

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[1] Chiefly from the annual reports of the commissioners of the state reservation.

[2] The hights vary from 4 to 20 feet with the elevation of the water in the river below the falls.

Mean annual recession of American falls between 1842 and 1890	.64	feet
Mean total recession of Horseshoe falls between 1842 and 1890	104.51	"
Mean annual recession of Horseshoe falls between 1842 and 1890	2.18	"
Length of crest line of American falls in 1842	1080	"
in 1890	1060	"
" Horseshoe falls in 1842	2260	"
in 1890	3010	"
Total area of rock surface which has disappeared at the American falls between 1842 and 1890	32,900	sq. ft
or	.755	acres
Total area of rock surface which has disappeared at Horseshoe falls between 1842 and 1890	275,400	sq. ft
or	6.32	acres

These changes are graphically shown in the successive crest lines of the Horseshoe falls, given in fig. 19, p. 81.

Volume of water passing over the falls each minute[1]	22,440,000	cu. ft
or	1,402,500,000	pounds
or more than	7,000,000	tons

Depth of water in the channel of Niagara river below the falls[2]: (*see* fig. 18)

At foot of Horseshoe falls (center)	150 to 200	feet
Upper Great gorge, from the falls to the beginning of the Whirlpool rapids (from soundings)	160 to 190	"
Whirlpool rapids	35	"
Whirlpool	150	"
Outlet of whirlpool	50	"
Opposite Wintergreen flat	35	"
Below Foster's flats	70	"

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[1] Blackwell, Am. jour. sci. 1844, 46 : 67.

[2] Estimated by Gilbert. Am. geol. 1896, 18 : 232-33 and elsewhere.

Width of Niagara gorge[1] (approximate):

Opposite the extreme west end of Goat island, and just in front of the Horseshoe falls	1250	feet
Opposite the center of the American fall	1700	"
Opposite inclined railway	1350	"
Between carriage and railroad bridges, narrowest point midway between the two	1000–1350	"
Just south of railroad bridges	950	"
Gorge of the whirlpool rapids	700–750	"
100 rods south of south side of whirlpool	1200	"
Same at water line	850	"
Inlet to whirlpool	1000	"
Same at water line	550	"
Outlet of whirlpool	900	"
Same at water line	450	"
South of Ongiara park	1300	"
Just south of Wintergreen flat	1600	"
River opposite Foster's flats (bottom)	300	"
Just south of Foster's flats (top)	1700	"
North of Devil's hole	1000	"
At the tunnel on the New York Central railroad (plate 12)	1300	"
Average width below Lewiston	2000	"

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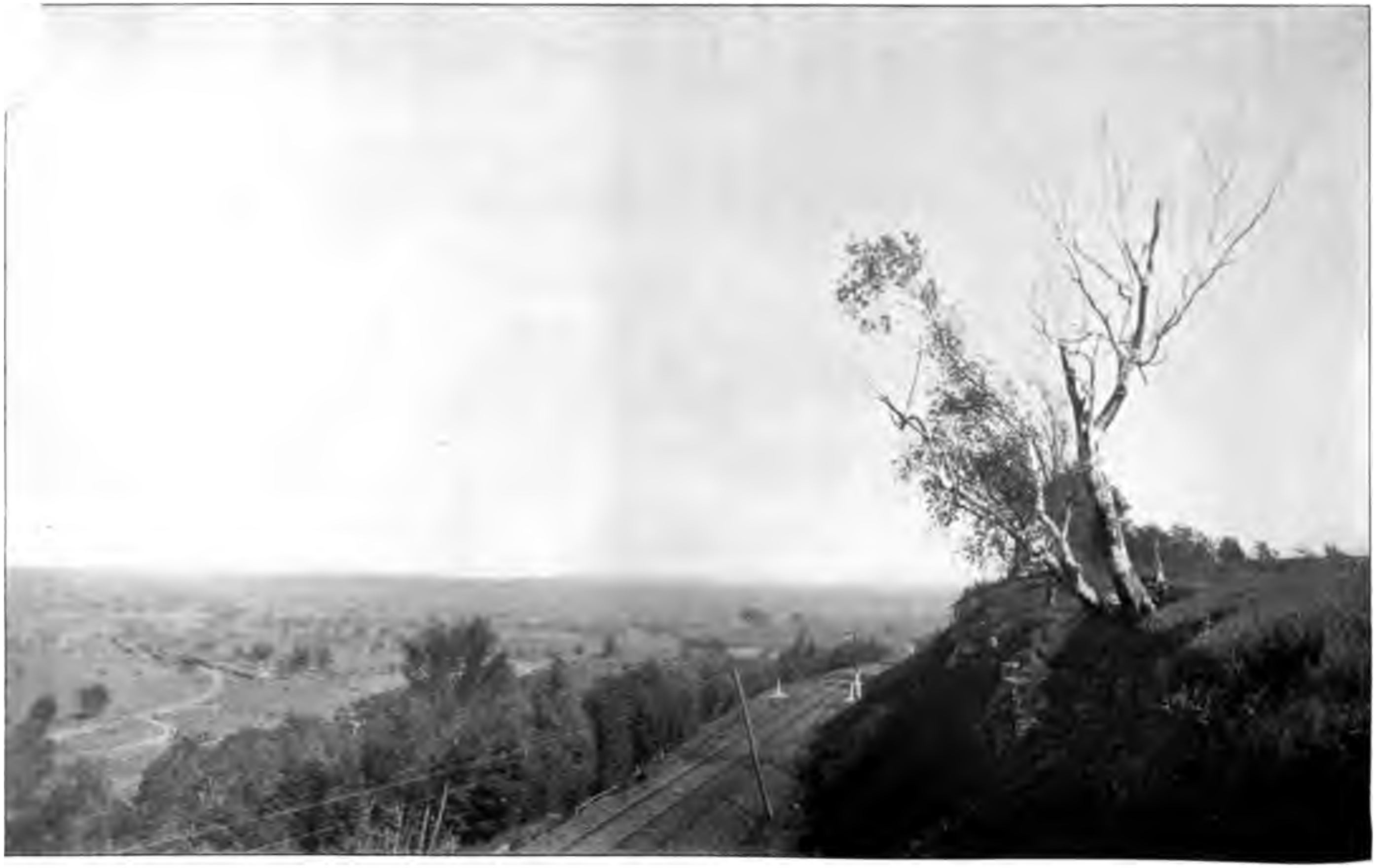
[1] Chiefly after Taylor. Bul. geol. soc. Am. 9 : 61-65. Top width is given unless otherwise stated.

Plate 3



The Niagara escarpment above Lewiston (inface of the Niagara cuesta). The lower plain (Ontario lowland) with Lewiston is seen on the left. The sandspit of the Iroquois beach is also shown. R. W. & O. railroad track in the foreground

Chapter 1

PHYSICAL GEOGRAPHY OF THE NIAGARA REGION

The physical geography of the Niagara region is of a relatively simple type, its main topographic features being readily interpreted. Unfortunately no very satisfactory birdseye view of the entire region can be obtained from any of the elevated points of the district; for the chief features are delineated on a scale too vast to be visible from a single vantage point. The best available spot from which a comprehensive view may be obtained is the summit of

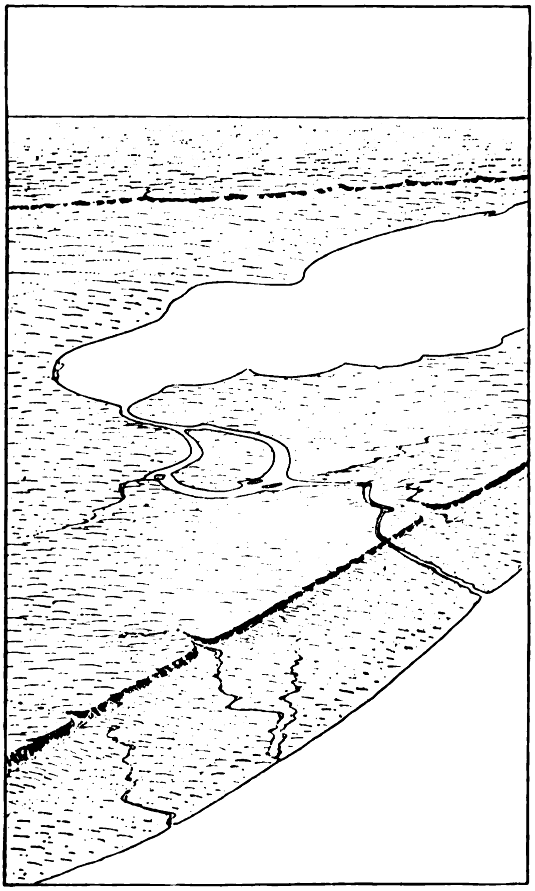


Fig. 2 Birdseye view of the Niagara region. (After Gilbert) The Niagara escarpment is shown in the foreground, with the lower plain sloping to Lake Ontario. The third upland belt is shown in the distance beyond Lake Erie. The second escarpment immediately north of Lake Erie, is not shown.

Brock's monument, which commands the hights above Queenston, on the Canadian side of the river. Looking northward from this elevation, the observer sees an almost level plain, cut only by the winding lower Niagara, stretching from the foot of a pronounced and often precipitous escarpment to the shores of Lake Ontario, 7 miles away. Ordinarily the distant northern shore of the lake is not readily recognized by the unaided eye, though on clear days a faint streak of land may be seen between sky and water on the distant horizon. A good field glass however will generally disclose the opposite shore, and the much eroded cliffs of Scarborough. Far beyond these, fully a hundred miles to the north of the observer, the crystalline rocks of the Laurentide mountains rise from beneath their covering of Paleozoic strata, as formerly they rose above the waters of the Paleozoic sea. These ancient Canadian highlands, together with the Adirondack mountains of New York, and the old crystalline regions of the Appalachians, constitute the chief visible remnants of the old pre-Cambric North American continent. The erosion of these ancient lands has furnished much of the material from which beds of later date in this region were derived. Some of these beds may be seen in the sections cut by the rivers through the deposits in comparatively recent times, and no more instructive example than the gorge of the Niagara need be cited.

In the banks of the lower Niagara gorge may be seen the cut edges of the red shales and sandstones of the Medina group, the brilliant color of which is in striking contrast with the greenish blue of the water, and the darker green of the foliage which fringes its borders. The plain above is dotted with farms, orchards and hamlets, and is one of the richest agricultural and fruit districts of the country. In the foreground, on opposite banks of the river, lie the sister towns of Queenston and Lewiston, former rival guardians of the head of navigation of the lower Niagara, but now for the second time joined by bands of steel across the intervening gulf. Farther down the stream Niagara-on-the-Lake and Youngstown crown respectively the left and right bank of the river. These four towns of the lower Niagara, hold daily communication by ferry, steamboat or electric railway; the last and the steam railway keeping them in touch with the cities of the upper Niagara and the world at large. This office is also performed by the well appointed steamboats which ply the lower Niagara, and carry passengers across Lake Ontario, to and from Toronto, the capital and metropolis of the province of Ontario. As these steamers enter or leave the Niagara river, they pass Forts Massassauga and Niagara which stand guard on opposite shores at the mouth of the river. The latter fort was established in 1678, and is rich in historic associations, while the Canadian fort is the modern successor of old Fort George, which was destroyed during the war of 1812.

When the observer on the Brock monument turns to the west or to the east, he sees the escarpment on which he stands, and the plain at its foot stretching in either direction beyond his field of view. The continuity of the escarpment is broken at intervals by ravines or gorges which dissect it, the most pronounced of these being the Niagara gorge in the immediate foreground. Westward from Queenston the escarpment is practically continuous for more than 3 miles, when, at the little town of St Davids, it is seen to recede abruptly, and a gap over a mile in width intervenes, beyond which it continues in force, with only minor interruptions, to Hamilton (Ont.), 40 miles west of the Niagara river. The gap at St Davids marks an ancient valley or gorge cut into the upland plateau which terminates at the escarpment. This old valley is traceable southeastward as far as the whirlpool, in the formation of which it has played a prominent part. It is filled throughout its greater extent by sand and clay, into which modern streams have cut gullies of greater or less magnitude.

Beyond St Davids, the escarpment, though indented by numerous streams, is as stated, continuous to Hamilton (Ont.). Here a larger and more pronounced interruption occurs, the escarpment being breached by a broad and deep channel, locally known as the Dundas valley. This ancient channel, with an average width of 2 miles or more, is traceable westward for a number of miles, when it becomes obliterated by drift deposits. Beyond the breach made by the Dundas valley, the escarpment continues in force, its direction however having changed to west of north, or nearly at right angles to its direction south of Lake Ontario. The eastern face of the Indian peninsula between Georgian bay and Lake Huron and the bold bluff of Cabot's head mark the northward extent of this escarpment, which, after an interruption by a broad transverse channel, is farther traceable in the northern slope of the Manitoulin islands. Eastward the escarpment continues to the vicinity of Lockport, where its continuity is interrupted by two pronounced gulfs, through one of which the Erie canal descends to the lowland of Lake Ontario. Beyond Lockport the escarpment becomes less pronounced; at first it separates into several minor steps or terraces and later it is replaced by a more or less continuous and gentle slope. Beyond the Genesee river it is no longer distinguishable, the surface of the country ascending gently and uniformly from Lake Ontario southward.

Turning now toward the south, the observer sees a second plain extending from the edge of the Niagara escarpment to where its continuity is blended with the horizon. This plain is not as uniform as the Ontario plain, which is fully 200 feet below it, and it is sharply divided by the Niagara gorge, from its northern edge at the escarpment to where, in the distance, a cloud of spray marks the location of the great cataracts. In the walls of the gorge can be seen the cut edges of the strata which enter into the structure of this higher plain, and attentive observation will reveal the fact, that the uppermost of these is a firm-looking limestone bed, which increases perceptibly in thickness toward the north. This thickening of the capping limestone bed, whose upper surface is essentially level, brings out a fact not otherwise readily noticed, namely that the strata all have a gentle inclination or dip to the south. The surface of the upper plain, aside from minor, mainly local irregularities, is essentially level, scarcely rising above the 600 foot contour line. This is the elevation, above the sea, of the base of Brock's monument, and it is the average elevation of the plain in the vicinity of Buffalo, the location of which, 20 miles to the south, is indicated by a perpetual cloud of smoke above the horizon.[1]

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[1] A very satisfactory view of the level character of this plain is obtained during a ride by rail from Niagara Falls to Lockport, and thence by train or electric car to Buffalo.

For many miles to the east and west of the Niagara river the plain does not change perceptibly in elevation. Nevertheless, there is a gradual eastward descent, till, on the Genesee river, the surface of the plain, where not modified by superficial deposits, is fully a hundred feet lower than at Niagara. Westward the plain rises gradually, its elevation near Hamilton averaging 500 feet above Lake Ontario, or considerably more than 700 feet above the sea.

Owing to the southward inclination of the strata of this region, the limestone bed which forms the capping rock at the escarpment, eventually passes below the level of the plain, having previously increased in thickness to over 200 feet. The disappearance of the limestone as a surface rock occurs near the northern end of Grand island, as shown by the accompanying geologic map, and from this point southward the surface rock is formed by the soft gypsiferous and salt-bearing shales of the Salina group, which overlie the limestone and in turn pass below the higher strata in Buffalo, where beds of limestone again become the surface rock. Throughout the area where the shales form the surface rock, the plain is deeply excavated on both sides of the Niagara river, a longitudinal east and west valley, now largely filled by surface accumulations of sand and gravel, being revealed by borings. Tonawanda creek occupies this valley on the east, though flowing on drift, considerably above its floor, and Chippewa creek occupies it in part on the west of the Niagara river. This valley, as will be shown later, can be traced westward into Canada and eastward to where it joins the Mohawk valley, with which it forms the great avenue of communication across the state of New York. The northern boundary of the Tonawanda and Chippewa valleys is formed by a limestone cliff similar to, though less pronounced than, the Niagara escarpment. This cliff, generally known as the second limestone terrace of western New York (the Niagara escarpment being the first), is formed by the upper Siluric limestones (Waterlime and Manlius limestone) and the Onondaga limestone of the Devonic series. The latter is a very durable rock and hence it forms a very resistant capping stone. This escarpment is scarcely visible at Black Rock, where it is crossed by the Niagara river, for here it is low, and, in addition, extensive drift accumulations have obliterated its topographic relief. Eastward and westward however it becomes prominent. A drive along Main street from Buffalo to Akron at the Erie county line will reveal the fact that it gradually increases in hight and boldness, till at the latter place it rises nearly a hundred feet above the Tonawanda valley, which itself is drift filled to a not inconsiderable extent. If we trace this escarpment into eastern New York, we find it progressively increasing in hight, owing to the interpolation, between the Manlius and Onondaga limestones, of the thick beds of the Helderbergian series, which, with the other lower Devonic beds, are entirely absent in the Niagara region, where their place is marked by an unconformity. (*See* figs.1 and 21-24)

If the observer changes his position to some elevated point near Buffalo, he may note that the plain which extends southward from the edge of the second escarpment, presents again a scarcely modified and almost level surface, which south of Buffalo gently descends to a third lowland, that of Buffalo creek and Lake Erie. Like the other lowlands, this one is carved out of soft rocks (Marcellus and Hamilton shales) and has subsequently been filled to some extent by drift deposits. This has been proved by borings which show that the bedrock in the valley of Buffalo creek is 83 feet below the surface of Lake Erie.[1] There are other excellent reasons for believing that the western end of this lowland, now occupied by Lake Erie, was once considerably lower than at present.

On the south the Erie lowland is defined by a range of hills, the northern edge of the great Allegany plateau, which forms the highlands of southern New York and northern Pennsylvania. There are no very pronounced declivities in the northern edge of this plateau in the Lake Erie region, owing no doubt to the relatively uniform character of the rocks composing it, there being no resistant capping bed of sufficient magnitude to produce an escarpment. Farther east, however, owing to the increasing thickness of the beds and their more resistant character, a prominent escarpment is developed, which near the Hudson unites with the escarpment of the lower series, and with it constitutes the prominent Helderberg range, which culminates in southeastern New York in the high plateau of the Catskills. The Allegany plateau is everywhere much dissected by streams whose gorges have made the scenery of southern New York famous.

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[1] Pohlman. Life history of Niagara. 1888. p. 4.

We have now seen that the topographic features of the Niagara district are arranged in a series of six east and west extending belts of alternating lowlands and terraciform elevations. The lowlands are the Ontario, Tonawanda-Chippewa, and Erie, the uplands are defined by the Niagara escarpment, the Onondaga escarpment and the hills of southern New York which constitute the northern edge of the Allegany plateau. The northern boundary of this belted country is formed by the old Canadian highlands.

We must now briefly consider the various strata of which the area under consideration is constructed, their origin, and the manner in which the topographic features of this region were produced. A brief review of the table of Paleozoic strata, given on pages 20 and 21, will be helpful to an understanding of the succeeding pages.

Development of the Paleozoic coastal plain

The Laurentian old-land is composed of rocks older than the Cambric period of the earth's history. These are largely of igneous origin, and such as were originally sediments have generally suffered much alteration through heat, pressure and other causes, and in most cases have assumed a more or less crystalline character. Though many of these pre-Cambric rocks may show apparent stratification, the present attitude of the beds does not often bear a close relation to their original condition. Indeed, these ancient rocks are generally much disturbed, their beds folded and flexed, and their laminae much contorted. Nor do the layers of the pre-Cambric rocks bear any normal relation to those of later date, the two series being wholly discordant with each other. The older beds are much worn, vast portions of the ancient folds having been swept away by erosion, and on the truncated edges of the remaining portions the newer strata were deposited in an essentially horizontal position. This *unconformity* of relation between the newer and older strata is a marked feature wherever the two series are exhibited in contact with each other. Generally the older rocks have been worn down to an undulating plain (or peneplain), and the succeeding beds made from the fragments which were worn from the old land.

In the area under consideration, the ancient erosion surface of pre-Cambric rocks was overspread by a deposit of sand and occasionally gravel, which commonly possesses characteristics pointing to a very local origin. Thus the pebbles found in the lowest layers of the covering sands, i. e. the Potsdam sandstone, are sometimes of the same lithic character as the crystalline rocks near by. The Potsdam sandstone is a shallow-water rock, and during its accumulation a progressive subsidence of the sea floor took place, thus allowing the deposition of beds of considerable thickness. This subsidence brought with it a northward migration of the shore line of the sea, so that the region of the former coast line gradually became more remote from the shore. As a consequence, land-derived material became less abundant in this off-shore district, being deposited mainly along the new coast line, while farther out to sea calcareous deposits, resulting in part from the shells of organisms became relatively more abundant. A profile through the strata of this region such as would be obtained in a well or shaft sunk to the crystalline floor would show a progressive decrease in the abundance of terrigenous material from the Potsdam sandstone upward to the top of the [illegible] limestone and a corresponding progressive increase in the amount of calcareous matter. This indicates a [illegible] subsidence of the sea floor, and hence a migration of the shore with its attendant terrigenous deposit. It would also be seen that the [illegible] character of any particular formation [illegible] the same throughout its extent [illegible] characteristics [illegible] show considerable variation. Close to the shore each formation would present a [illegible] character [illegible] would show [illegible] sandy [illegible] layers [illegible] each formation [illegible] calcareous [illegible] increase in [illegible] with the increase in distance [illegible] the source of supply of [illegible] sediment. Thus the Potsdam [illegible] calcareous [illegible] sandy layers with layers [illegible] connecting [illegible]

The Utica shales and the arenaceous Lorraine shales which follow on the Trenton limestones show a return of land-derived deposits due probably to a shoaling of the water. This may have been caused by an upward movement of the sea bottom or by a partial withdrawal of the water into deepening oceanic basins. Some abrupt change is indicated by the sudden transition from limestone to black shale. Another abrupt change occurred at the close of the Ordovicic era, as indicated by the marked contrast between the Lorraine shales and the Oneida and Medina beds which immediately succeed them.

The Siluric deposits of this region began as shallow water accumulations, the lowest bed being the Oswego sandstone, which farther east, is replaced by the conglomerates of Oneida county and the Shawangunk range. The marls and shales of the Medina series succeed these sandstones with an aggregate thickness exceeding 1100 feet. A heavy stratum of gray quartzose sandstone, varying in thickness up to 25 or 30 feet, separates, in the Niagara region, the lower from the upper Medina shales and sandstones, which have an approximate thickness of 100 feet. The Clinton shales and heavy limestones follow on the Medina, with a thickness averaging 30 feet. The Rochester shales, with a thickness of 60 to 70 feet, follow the Clinton limestones and are in turn succeeded by the Lockport limestone, whose average thickness, obtained from well records, approximates 250 feet in this region. The Salina shales succeeding the Niagara beds (Rochester shales and Lockport limestone) have an aggregate thickness of less than 400 feet, and are followed by the Waterlime and the Manlius limestone, the former averaging 50 feet in thickness, the latter from 7 to 8 feet. The lowest Devonic beds are absent in this region, the Onondaga limestone resting directly on the Manlius beds, there being, as before noted, an important though not very pronounced unconformity between the two. A glance at the geologic map of this region will reveal the fact that the lower strata rise from under the covering newer beds on the north, and occupy a belt of country of greater or less width according to the thickness of the beds. Where they come to an end, the next lower beds make their appearance. The discontinuation of the higher beds northward is due to a thinning out of the exposed portion of the strata, as can be readily seen in the Lockport limestone bed, which is less than 30 feet thick at Lewiston, but more than 80 feet at the falls, increasing in thickness southward to 250 feet or more. Where, however, the strata are not exposed on the surface, i. e. where they are only shown in sections under cover of the overlying rock, no such thinning is seen. This may be observed in the case of the Clinton beds and the upper Medina sandstones. In some cases these beds are seen to even thin southward, as proved by borings. The thinning of these strata does not, as is often assumed, mark the original thinning of the beds toward the shore on the north, but is evidently due to erosion. A brief résumé of the origin of the various strata will make this clear.

The Medina sandstone is an ancient shore and shallow water deposit, as will be more fully pointed out in chapter 3. The sands and gravels, which with some finer muds, make up this rock, are all derived from some preexisting land. The only source of supply was the old Laurentian land on the north and the Appalachian old-land on the south. It is true that, owing to the elevation at the beginning of Siluric time, some of the pre-Siluric stratified rocks may have been raised above the sealevel and added to the old-land, and that part of the Medina sands may have been derived from these. Even then the largest amount of detritus was probably derived from the crystalline old-lands, the progressive accumulation of 1200 feet of Medina rock marking a corresponding subsidence and a concomitant encroachment of the seashore of the Medina sea on the old-land. Thus the Medina deposits gradually overlapped the Ordovicic and Cambric deposits and probably eventually came to rest entirely on the crystalline pre-Cambric rocks. Continued subsidence, at least in the Niagara region, produced the purification of the water, so that eventually the limestones of the Clinton epoch could be formed in a region remote from that in which terrigenous material was accumulating. This was likewise true of the Lockport limestone, which was deposited after an interval, during which the calcareous shales separating the two limestone series accumulated. While these deposits, particularly the limestones, point to a considerable distance from the shore line, we are by no means at liberty to assume that no shore formations accumulated during this period. In fact, it would be difficult to understand the non-accumulation of terrigenous material along the shores of any land during any period of the earth's history unless such land was without even moderate relief. As will be shown in chapter 3 there are reasons for supposing that a considerable land barrier existed in the north as well as the east and southeast, and thus we may assume that shore deposits of terrigenous material were formed while the limestones were accumulating in the clearer waters. That the shores of this period did not consist of Medina sandstone is indicated by the absence of any such material in the shales of either the Clinton or Niagara series. It is highly probable that the shore was still formed by the old crystalline highlands, and that the accumulating Clinton and Niagara sediments overlapped and completely buried the Medina beds. The limestones are chiefly fragmental in origin, being composed of calcareous and magnesian sands. These, as will be shown later, were largely derived from the destruction of coral reefs and shells growing in the immediate neighborhood. They indicate shallow water, a conclusion emphasized by the occurrence of well marked cross-bedding structure in some of the beds of limestone. We may assume a gradual passage from pure calcareous beds to beds consisting more and more of terrigenous detritus as we approach the old shore line, where quartz sands probably constituted the chief material of the deposits.

We may obtain an approximate indication of the former extent of these strata if an attempt be made to restore the portions which must have been removed by erosion. We may consider the Clinton and Niagara as a unit, assuming that near the old shore their beds were practicably indistinguishable. The average dip of the strata of this region is 25 feet to the mile (a moderate estimate, as the dip ranges up to 40 feet), and the base of the Clinton-Niagara is approximately 400 feet above sea level. Continuing this dip northward for a hundred miles to where the present borders of the oldland are exposed, the base of this group would have risen 2900 feet above the sea, an elevation sufficient to overtop the highest peak of the present Laurentides; for, according to Logan, "in the country between the Ottawa and Lake Huron the highest summits do not appear to exceed 1500 or 1700 feet, though one . . . probably attains 2300 feet".[1] We assume of course with good reason that the Laurentides at that period were much higher than now, for they must have suffered enormous erosion during the long interval since the close of Siluric time.[2]

Since the deposition of these Siluric strata the region under consideration has suffered an enormous amount of denudation, having been brought to the condition of a low nearly level tract or *peneplain*, but little above sea level, not once, but probably a number of times, separated by periods of elevation and at least one of subsidence. The present surface of the Niagara plateau is therefore not to be considered as identical with the old surface of deposition, but as due to prolonged peneplanation, or erosion to near sealevel, completed probably toward the close of Mesozoic or the beginning of Cenozoic time. The following diagram (fig. 3) will illustrate the relation between the strata and the surface of the land at 1) the close of Siluric time, 2) late Mesozoic or early Cenozoic time, after the completion of the last cycle of erosion and the reduction of the land to peneplain condition, and 3) the present surface.

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[1] Logan. Geol. Canada. 1863. p. 5.

[2] The Niagara beds of Lake Temiscaming, in the great pre-Cambric area of Canada and 150 miles distant from the nearest beds of the same age, are of interest in this connection. They occupy an area about 300 miles due north of Lewiston and on the north side of the present Laurentide chain. According to Logan they do not properly belong to the former extension of the Niagara beds of the region under consideration, but rather to the Hudson bay area on the north. They are of interest however as showing the great former extent of these formations. They lie unconformably on the pre-Cambric rocks, and the basal members are generally sandstones and often conglomerates "containing large pebbles, fragments, and frequently huge boulders of the subjacent rock" (Logan, p. 335). The thickness of the formation here is estimated at between 300 and 500 feet. The Ordovicic and Cambric strata are absent, showing a progressive encroachment of the sea on the old-land, and a consequent overlapping of the strata. Outliers of earlier strata are found in more southern portions of Canada, resting on the pre-Cambric surface, and many of these indicate a progressive overlapping of later over earlier beds. Lawson holds that this indicates, that most of the Canadian old-land was covered by the early Paleozoic strata, and that erosion since Paleozoic time has resulted in simply removing these overlying rocks. (Bul. geol. soc. Am. 1 : 169 et seq.) He holds that comparatively little erosion of the old-land has occurred since Paleozoic time, the present surface being essentially pre-Cambric and only revealed by stripping of the overlying rocks. It is not improbable however that some of these distant outliers may have been preserved during the extensive denudation of the old-land, by having been faulted down previously in a manner well known to have occurred in the Scandinavian old-lands, a solution suggested to me by my friend, A. W. G. Wilson, of Harvard university.

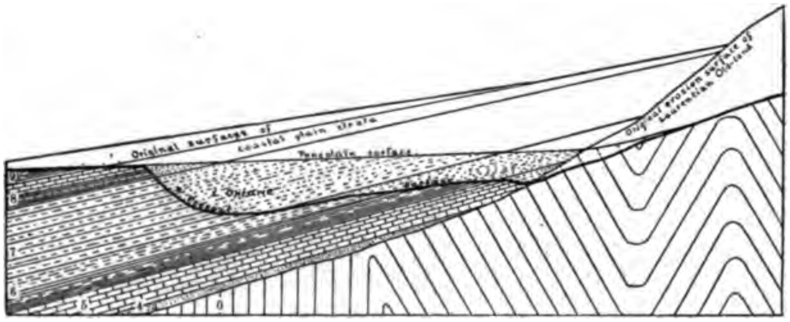


Fig. 3 Diagram of ancient Paleozoic coastal plain, and its relation to the Mesozoic peneplain surface and the present land surface. The numbering of the beds corresponds to that of the table.

Between the close of the Siluric and beginning of Mesozoic time a long period intervened, during which this region was at first a land surface, suffering considerable erosion, but later was resubmerged, and covered with extensive deposits of Devonic limestones, shales and sandstones. The final emergence took place at the close of Paleozoic time, the succeeding Mesozoic time being in this region probably an uninterrupted period of erosion, during which the land suffered the combined attacks of the atmosphere and of running water.

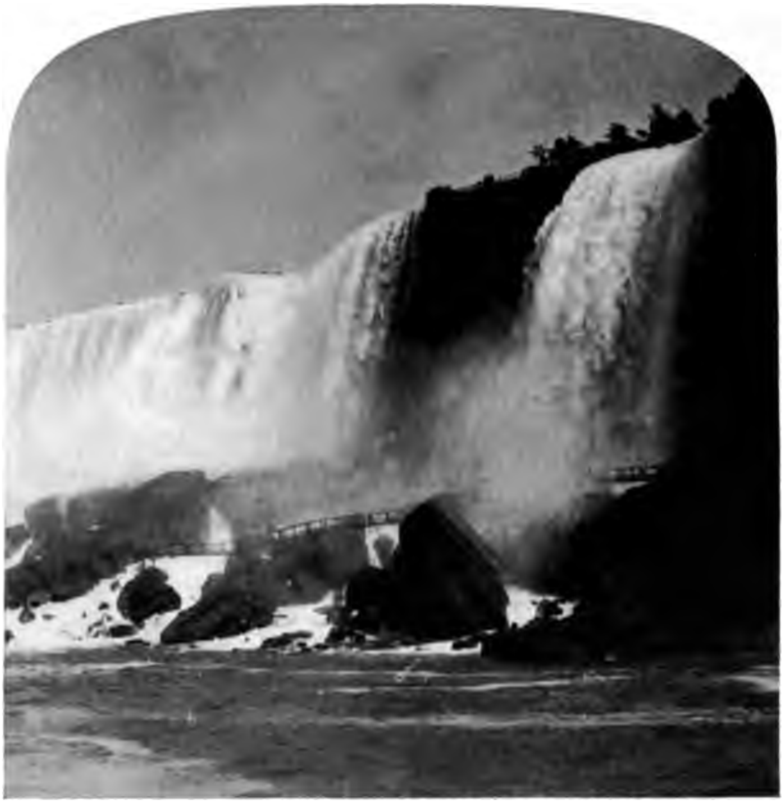
Development of the drainage features

The water which falls as rain or snow on the land either evaporates, runs off on the surface, or sinks into the ground, where it constitutes the ground water. That which evaporates, accomplishes little or no direct geologic work, but both the surface and underground waters are important geologic agents. If the surface on which the water falls is a perfectly smooth but inclined plain, the water will run off in the form of a thin sheet. A perfectly smooth land surface is however unknown, and the run-off of the surface waters is always concentrated along certain lowest lines, thus constituting brooks, streams and rivers. While there may be numerous drainage lines of this type, they generally unite into a few master streams, the direction of whose flow is down the inclination of the surface of the land. Such streams are known as *consequent* streams, their direction of flow being consequent on the original slope of the surface.

When the strata of the Niagara region became a part of the dry land, from the relative lowering of the water level (which may have been due to rise of the land or to drawing off of water by the deepening of the oceanic basins), they formed a broad, essentially monotonous belt of country fringing the old-land on the north, i. e. a marginal coastal plain. The strata of this plain had a gentle southward inclination, a feature shared by the surface of the plain. Consequent streams quickly made their appearance on this plain, a number of them probably coming into existence almost simultaneously and running essentially parallel from the old-land, across the new coastal plain into the sea. These streams soon cut down into the coastal plain, carving channels for themselves and thus establishing definite lines of drainage. As the streams at first consisted entirely of the run-off of the moisture which fell on the plain and in the higher old-land portion, it is evident that, unless the rainfall was continuous, or unless extensive snow fields were present to supply water, these young streams must have fluctuated greatly in volume of water, and at intervals become entirely dry. This condition continued till the valleys, cut by these streams of run-off water, had become sufficiently deep to reach the level of the underground water, when the supply, augmented by springs, became much more constant. Thus in course of time large valleys, supplied with large rivers, came into existence. Meanwhile the sides of the river valleys were attacked by the atmosphere, and degradation of the cliffs cut by the stream resulted.

As long as a river is narrow and vigorously undercuts its banks, the latter will be steep, and the river channel will have the character of a gorge. This generally continues as long as the river is cutting

Plate 4



American and Luna falls from below, with limestone fragments fallen from the cliff above (Copyright by Underwood & Underwood, New York)

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downward, i. e. till the grade of the river bottom is a very gentle one, when lateral swinging widens the gorge by undercutting the banks, and atmospheric degradation quickly destroys the steep cliffs which the river does not keep perpendicular.

During the process of drainage development, numerous side streams come into existence, which join the main stream as branches. These begin as gullies formed by the rainwater running over the sides of the banks into the main stream. A slight depression in the surface, or a difference in the character of the material composing the banks, may determine the location of such a gully, but, once determined, it will become the cause of its own farther growth. For the existence of this gully will determine the direction of flow of succeeding surface waters, and so in the course of time the gully will become longer and longer by headward gnawing, till finally a channel of considerable magnitude is produced. Streams of this type are known as *subsequent* streams, and they very generally have a direction varying from a moderately acute to nearly a right angle with reference to the main or consequent stream.

As the dissection of the Niagara coastal plain continued, the higher portions of the strata, i. e. those nearer the old-land, were slowly removed, and the beds lying beneath these were thus exposed. The latter strata were generally of a more destructible character than the overlying ones, and on this account great lowlands, parallel to the old shore line, or the line of strike of the strata, were worn in them by subsequent streams. The more resistant beds, meanwhile, favored the formation of more or less prominent cliffs or escarpments which faced the lowlands, and being undermined slowly retreated southward, thus increasing the width of the lowlands. These features are today repeated in the Niagara escarpment which faces the Ontario and Georgian bay lowlands, and the escarpments formed by the outcrops of the Ordovicic limestones farther north. The diagram, fig. 4, illustrates the probable condition during early Mesozoic time. The great master consequent streams indicated are: the Saginaw, the Dundas and the Genesee, flowing from the old-land on the northeast, southward or southwestward into the Mesozoic interior sea. There were probably other consequent rivers, whose location may be in part indicated by some of the valleys now occupied by the Finger lakes of New York. Subsequent streams, flowing along the strike of the beds and capable of accomplishing much erosion by undermining the resistant capping beds of the escarpments, continued to widen the longitudinal (i. e. eastwest) lowland areas, while the transverse valleys of the consequent streams remained relatively narrow.

The topographic relief feature produced by this normal development of drainage on a young coastal plain consisting of alternating harder and softer strata, has been named a " cuesta ",[1] and may be briefly defined as an upland belt of slightly inclined coastal plain strata, with a surface gently sloping toward the newer shore, and a steep escarpment, or *inface*, fronting a low belt, or *inner lowland*, which separates the cuesta from the old-land upon which its strata formerly lapped. The existence of the cuesta form is usually due to a more or less resistant stratum overlying a less resistant one, as, for example, the limestones overlying the upper Medina shales. The inface of the cuesta is continually pushed back by the undermining subsequent streams, aided by atmospheric attack, and thus the belt of low country, lying between the cuesta and the old-land, is continually widened, while during the same time the valley of the transverse consequent stream which carries out the drainage increases comparatively little in width. It must be remembered however that the lowland can never be deepened below the depth of the valley of the consequent stream which carries its waters through the breach in the cuesta.

While the main drainage of this region was undoubtedly southwestward by consequent streams, which flowed through the cuesta in gorges, and by subsequent streams flowing into the former, and occupying the inner lowlands, short streams, flowing toward the old-land, down the inface of the cuesta, were probably not uncommon. These streams began to gnaw gullies back from the inface of the cuesta, and ultimately prolonged these gullies into gorges, and carried the drainage into the subsequent streams. Streams of this type, which have their representatives in all coastal plain regions, have been called *obsequent* streams,[1] their direction of flow being opposite to that of the consequent streams. The following diagram (fig. 4) illustrates this type of a stream and its relation to the subsequent and consequent streams. To this type of stream belongs the ancient St Davids gorge, as will be shown more fully in subsequent pages.

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[1] Davis, W M. Science. 1897. New series. 5:302; *also* Textbook of physical geography. 1898. p. 133. Pronounced kwesta, a word of Spanish origin " used in New Mexico for low ridges of steep descent on one side and gentle slope on the other ".

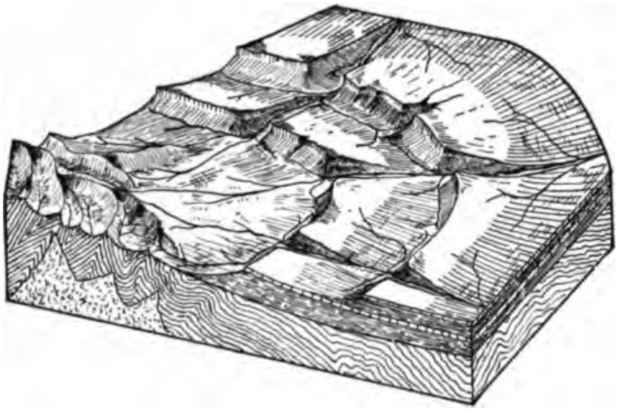

Fig. 4 Diagram of a portion of a dissected coastal plain, showing old-land on the left, and two cuestas with their accompanying inner lowlands. Three consequent streams have breached the cuestas, and subsequent streams from the lowlands join them. An obsequent stream is shown in the center of the outer cuesta.

If we assume that during the greater part of the Mesozoic era, the land in this region remained in a constant relation to the sealevel, it becomes apparent that the southward retreating infaces of the cuestas formed by the resistant members of the Paleozoic rocks, became lower and lower, as the southward inclination of the strata carried the resistant beds nearer and nearer to sealevel. Eventually the escarpment character of the infaces must have become obsolete, from the disappearance, beneath the erosion level, of the weaker lower strata, which permitted the undermining of the capping beds. When this occurred, the capping strata alone continued exposed to the action of the atmosphere, and, from a cliff character, their exposed ends were planed off to a wedge shape, thinning northward at a rate proportional to the dip of the beds. The ultimate result of all this erosion was the reduction of the land to a low peneplain, which did not rise much above the sealevel. Portions of this peneplain are today preserved in a scarcely altered condition, in the Niagara upland, the region about Buffalo and other localities. The slight change which these regions have subsequently undergone leads to the supposition that the peneplain was completed in comparatively recent geologic time, possibly at the beginning of the Tertiary era, or even more recently. This is also shown by the comparative narrowness of the valleys cut into the peneplain surface in preglacial times. The present altitude of this peneplain in the vicinity of the Niagara river is approximately 600 feet above sealevel, while southward it rises. There is however good presumptive evidence, some of which will be detailed later, that, during a period preceding the glacial epoch, the land in the north stood much higher than at present, so that the slope of the surface was southward. An accentuation of slope would cause a rejuvenation of the consequent streams, which, in the later stages of peneplanation, had practically ceased their work of erosion on account of the low gradient of the land. As a result of the renewal of erosive activity the early Mesozoic topography was in a large measure restored, but the inface of the Niagara cuesta, the top of which is now found in the Niagara escarpment, occupied in the restored topography a position considerably farther to the south than that characteristic of early Mesozoic time.

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[1] W. M. Davis

We may now examine more in detail the channels of the consequent streams which dissected this ancient coastal plain, and the extent of the inner lowlands drained by the subsequent streams tributary to them.

Dundas valley The Dundas valley appears to have been the outlet for the major consequent stream of this region, the Dundas river. This valley, as before noted, breaches the escarpment at Hamilton (Ont.) near the extreme western end of Lake Ontario. The valley has been carefully described by Spencer, who considered it the pathway of the preglacial outlet of Lake Erie into Lake Ontario, the drainage of the Erie valley being in his opinion by a river which followed the present course of the Grand river, above Cayuga, past Seneca and Ancaster into the western end of the Ontario valley. It is extremely doubtful that such a stream ever existed, certainly it is highly improbable that the Dundas valley owes its existence to any stream which flowed eastward or toward the old-land, for it is altogether too broad, and continues too uniformly to permit its being regarded as the valley of an obsequent stream. Moreover, its peculiar position at the elbow of the escarpment is most suggestive of a consequent origin, for we would expect the face of the cuesta to make a reentrant where the master stream gathers its converging tributaries and flows out through a great breach in the cuesta.

The Dundas valley is 5 miles wide at Hamilton but rapidly decreases in width to 2 or 2½ miles at the top, where the limestone forms decidedly sharp summit angles (Spencer). Its northern wall has been traced westward for 6 miles to Copetown, and its southern for 3½ miles to Ancaster. Beyond these points the valley is filled with drift which has been much dissected by modern streams. The axis of the gorge is about n 70° e, and the glacial scratches observed on the rock surfaces at its summit, with few exceptions, make angles of 30° or more with it (Spencer).

At Hamilton the bedrock was found to be absent to a depth of 227 feet below the surface of Lake Ontario. The well from which this record was obtained is about 1 mile distant from the southern side of the Dundas valley, which is here 5 miles wide. The total known depth of the canyon is, according to Spencer, 743 feet, but he calculates that it reaches 1000 feet near the center.[1] Along the northern shore of Lake Erie well records have shown the absence of drift to a considerable depth. Thus, according to Spencer, at Vienna, 100 miles due west of Buffalo, the drift is absent to a depth of 200 feet below the surface of Lake Erie, while at Port Stanley, 20 miles farther west, it is absent to a depth of 150 feet below the lake. At Detroit the drift is 130 feet deep. At St Marys on the northwest and Tilsonburg on the southeast of a line connecting

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[1] Spencer. Pa. geol. sur. Q 4. p. 384-85.

Port Stanley with Dundas, Devonic limestones occur at a considerable elevation above Lake Erie (Spencer). Hence the southwestward continuation of the Dundas channel must be placed between

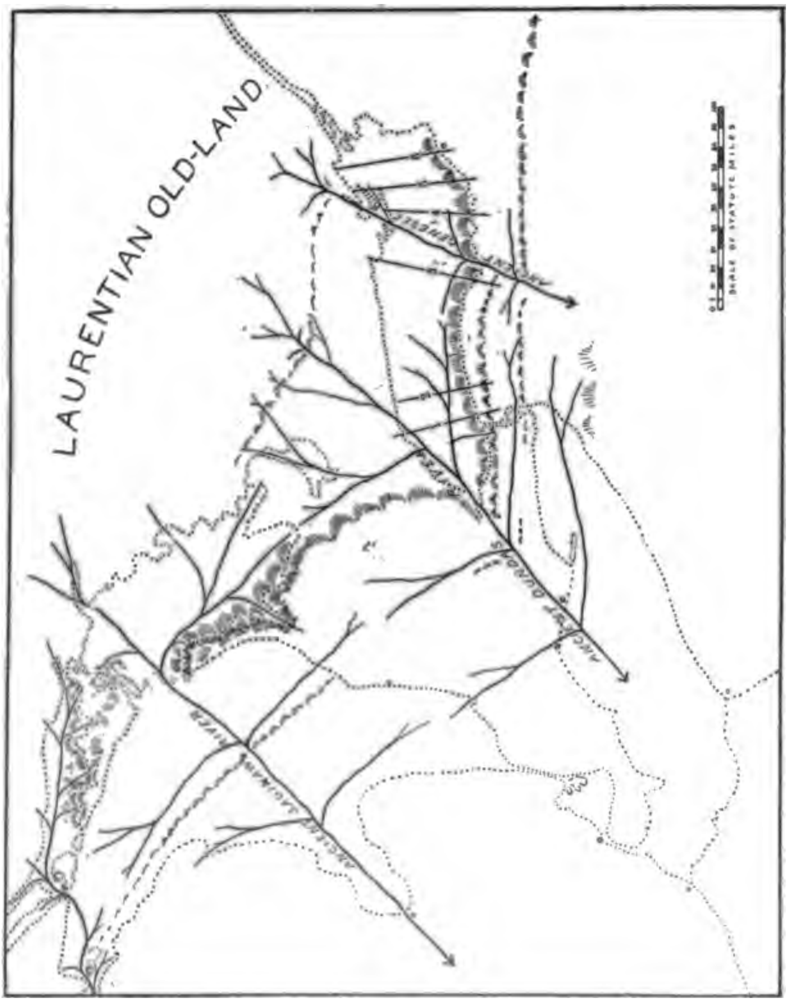

Fig. 5 Diagram showing type of drainage existing in Tertiary times in the Laurentian region.[1]

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[1] These maps are intended merely to illustrate the *kind* of drainage, which it is believed existed in preglacial times in the Laurentian region. The ancient consequent streams are probably correctly located; yet it must be stated that the region between Hamilton and Port Stanley has not been sufficiently explored to make the course indicated certain. These consequents may have had a more indirect course, for if the country was worn down to peneplain condition, as appears to have been the case, these st ve learned

these two points. On the southern shore of Lake Erie borings have revealed numerous deep channels. Thus the bottom of the ancient channel of the Cuyahoga river is reached, according to

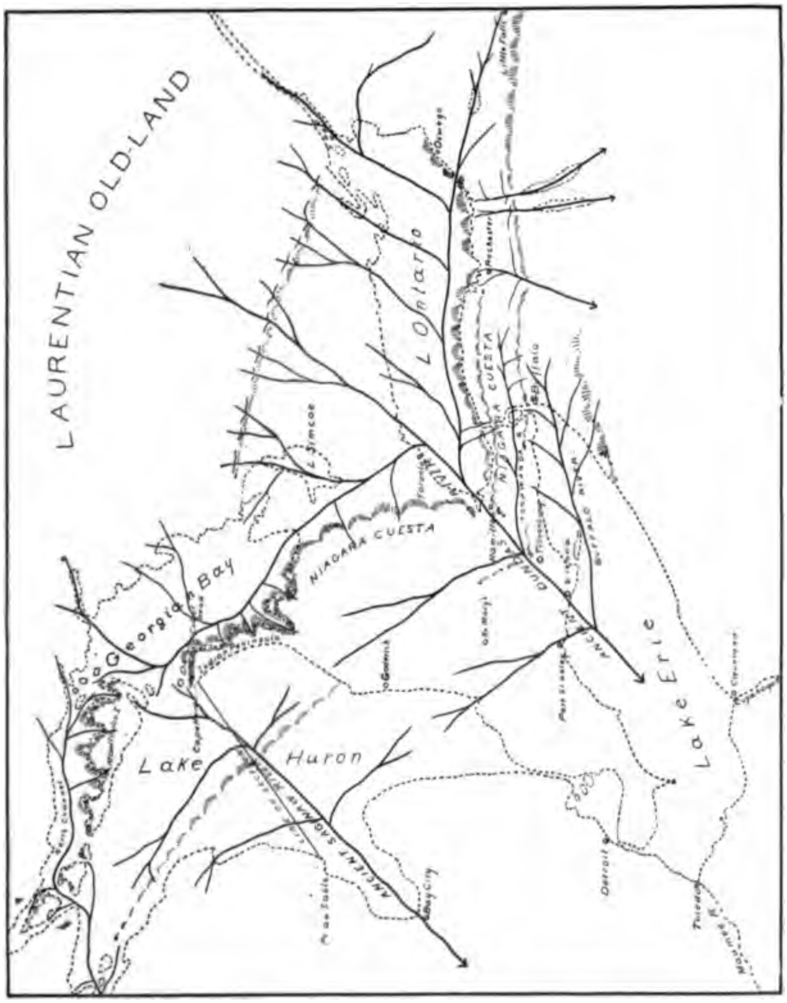

Fig. 6 A hypothetic later stage, showing adjustments which are suggested by existing relief features.

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to meander on this surface, the meandering course being retained on re-elevation. The depth of the bed rock at Port Stanley and Vienna, however suggests that a direct channel exists as shown on the map. The principal subsequents are probably located with approximate correctness, but the smaller branches are added without attempt at correctness. They were probably much more numerous than here shown.

Upham,[1] at a depth of more than 400 feet below Lake Erie. Whether this marks the former southward continuation of the preglacial Dundas river or whether that river turned more to the west, following in general the course of the present Maumee, must for the present remain unsettled. The Dundas undoubtedly became eventually tributary to the Mississippi.

Preglacial Saginaw river. The existence of an ancient river, flowing southwestward from the Canadian old-land across the valley of Lake Huron and the lower peninsula of Michigan, and finally becoming tributary to the ancient Mississippi, is indicated by the present character of the topography of that region. The Niagara cuesta is breached by a deep channel which now connects Georgian bay with Lake Huron, and which, north of Cove island, an outlier from the Indian peninsula, has been sounded to a depth of over 300 feet. This channel is in direct line with that of Saginaw bay, and, though this latter is at present very shallow, borings at Bay City show an absence of rock to a depth of at least 200 feet below the surface of the bay. At Alma (Mich.) the rock was shown to be absent to a depth of 350 feet below Lake Huron (Spencer); and, as this locality lies to the southwest of Saginaw bay and in line with the trend of its axis, we may assume that our preglacial Saginaw river was located here. Our limited knowledge of the preglacial topography of this region forbids tracing this channel beyond this point. Dr Spencer many years ago traced out this line of drainage, but he assumed that the river which occupied this channel, and which he has named Huronian, flowed northeastward to join that part of the ancient St Lawrence, or Laurentian river, which he supposed to have occupied Georgian bay.

Preglacial consequent Genesee river. Among the numerous consequent streams which flowed from the old-land southward or southwestward and which eventually became tributary to the preglacial Mississippi, probably through the ancient Ohio,[2] the preglacial Genesee river is the only other that can be mentioned here. Though now flowing northward on account of the tilting of the land, we may assume that much of its valley was carved by a southward flowing stream, the bottom of which, as shown by borings, was considerably below the floor of the present river. Whether Irondequoit bay is a part of this ancient channel, or whether it marks the position of an obsequent stream, must remain for the present an open question. Soundings in Irondequoit bay show a depth of 70 feet, though the rock bottom is probably much deeper.

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[1] Bul. geol. soc. Am. 8: 7.

[2] Westgate, Lewis. Geographical development of the eastern part of the Mississippi drainage system. Am. geol. 1893. 11:245-60. The Ohio, according to Newberry, flows nearly throughout its entire course in a channel, the rock bottom of which is nowhere less than 150 feet below the present river. The rocks at the "falls of the Ohio" show that at that point the river is not following the ancient course.

As soon as the consequent streams began cutting down their valleys again after the continental uplift which followed the period of peneplanation, the lateral subsequent streams began once more to open out broad lowlands in the weaker beds which now had become extensively exposed. These lowlands, in part now filled by drift deposits, are the Ontario and Georgian bay valleys, the latter continued in the North Passage, all carved out of the weak Medina and Lorraine shales; the Tonawanda-Chippewa valley, with the deeper portion of the Huron valley farther west, carved out of the soft shales of the Salina group; and the valley of Lake Erie cut out of the softer middle and upper Devonic shales. A few of these may be considered in greater detail.

Ontario valley. It is a well known fact that Lake Ontario is deeper in its eastern than its western part. In the following six cross-sections (fig.7), constructed from the lake survey charts, the greatest depths from west to east are 456, 528, 570, 738, 684 and 576 feet. The section showing the greatest depth is that from Pultneyville to Point Peter light, in the eastern third of the lake. As the present level of Lake Ontario is 247 feet above the sea, the deepest sounding recorded in these sections is 491 feet below present sealevel. From this point of greatest depth, the floor of the lake rises eastward, at first at the rate of 3 feet in the mile, and later at an average rate of 9 feet a mile. The valley appears to be continued south of the Adirondacks in New York along the present course of the Mohawk river, which flows at present several hundred feet above the rocky floor of the valley.[1] This floor ascends eastward, till at Littlefalls

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[1] Carll. Pa. geol. sur. I^3:363.

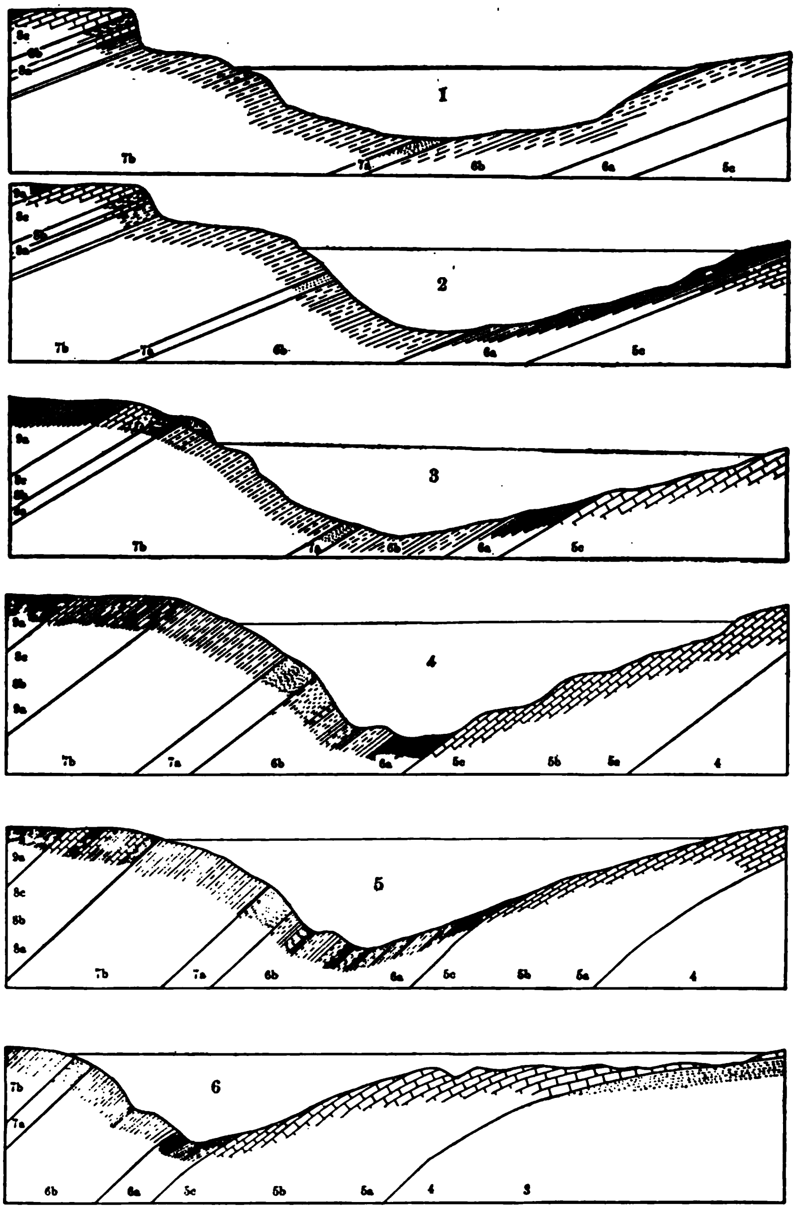

Fig. 7 Six cross-sections of Lake Ontario showing topography and geology. Vertical scale 1 inch = 1280 feet; horizontal scale 1 inch = 15¾ miles. Numbering of beds as in table; location of sections indicated in fig. 5. Section 1) E. of Niagara to E. of Pickering light. 2) Lockport to Darlington light. 3) West of Genesee to Presque Isle light. 4) Pultneyville to Point Peter. 5) West of Fair Haven light to False Buck light. 6) Oswego to Kingston.

the preglacial divide has an elevation of 440 feet above sealevel.[1] The following diagram (fig. 8) shows the present relation of the deepest part of the channel of Lake Ontario to sealevel, and the relation which would result by a tilting of the land back to its probable position in preglacial times. The last profile shows a continuous westward slope of the floor of the valley, steeper in the eastern portion, where the rocks are harder and the valley narrower, and more gentle in the western portion, where the softer rocks have allowed the opening of a broad lowland.

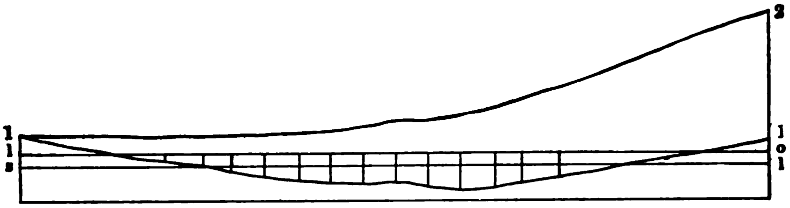

Fig. 8 Diagram showing the present deepest e-w channel of Lake Ontario along line 1-1, and its relation to sealevel s. l. and the level of Lake Ontario l. o. At 1, left side of diagram is represented the bottom of the channel at Vienna, 200 ft below level of Lake Erie or 370 ft above sealevel. At 1, right side, is the divide at Littlefalls 440 ft A. T. The line 1-2, is the line 1-1, but elevated on the east (right) so as to give a continuous westward drainage. Horizontal scale 1 inch = 100 miles. Vertical scale 1 inch = 4000 feet.

Numerous theories have been advanced to account for the deep basin of Lake Ontario. Spencer believed it to have been formed by an eastward flowing stream, the ancient Laurentian river, which received the Erian river as a tributary through the Dundas valley. The eastward continuation of this river Spencer believed to have been essentially along the course of the modern St Lawrence, the present great elevation of the rocky bed of this stream, above that of Lake Ontario, being explained by a warping of the land. Upham also believes that the basin is in part due to warping, but he considers it the valley of a westward flowing stream. Russell also holds this latter view; for he says[2] that, "previous to the glacial epoch, the greater part of the Laurentian basin discharged its waters southward to the Mississippi and . . . during the first advance of the ice from the north the drainage was not obstructed so as to form important lakes". Westgate[3], in tracing out the development of the Mississippi drainage system, considers that the flow of the Laurentian drainage system was southward into the predecessor of the Ohio river. As has already been shown, Spencer's eastward flowing river system can be originated only by a complete readjustment of the drainage, resulting from a great relative depression of the eastern uplands. Such a system could only come into existence after the valleys had been formed for it, and hence, as far as the history of the lake basins is considered, no such river system is required, and, unless positive proof of its former existence is forthcoming, it may be dismissed as hypothetic. One of the most important theories of the origin of the Ontario and other lake basins, and one which has had, and still has many prominent advocates, is that of glacial erosion, either entire or preceded by river erosion. This explanation was first most strongly urged by Prof. Newberry, and it has found its most recent able supporter in Prof. Tarr. It is impossible to do full justice to this view in the present limited space. Ice erosion is a factor the potency of which has often been overlooked, but of the importance of which there can be no question. We may however question whether a valley which, like that of Ontario, lies transverse to the general direction of ice movement in this region, can owe much of its depth to this agent. The following considerations will be helpful in understanding the influence of glacial erosion on preexisting topography. If a valley like that of Lake Ontario is occupied by a glacier the motion of which is parallel to the trend of the valley, the topographic relief is likely to be accentuated by ice erosion. If the motion of the ice is transverse to the direction of the valley, the erosion tends to obliterate or at least reduce the relief features. If, however, a mass of ice remains stagnant in the valley, the upper strata of ice may override it, and the amount of glacial erosion is reduced to a minimum. The striae in this region, together with the direction of slopes from the oldland, point to a southward movement of the ice, and Gilbert has shown that the amount of erosion on the edge of the escarpment in western New York is comparatively slight.[1] Hence we may assume that the basin of Ontario was mainly *occupied* by ice during the glacial period, but that comparatively little erosion was accomplished. This is farther borne out by minor relief features, such as the benches shown in sections 4, 5 and 6, in the southern wall of the basin, and which probably consist of harder beds which erosion has left standing out in relief. On the theory of glacial erosion, we might expect these to be absent, or at least much less prominent, since ice would hardly show such selective power as is attributable to running water and atmospheric agents.

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[1] Bigelow. Bul. geol. soc. Am. 9:183.

[2] Lakes of North America, p. 97.

[3] *Loc. cit.* p. 92.

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[1] Bul. geol. soc. Am. 11:121.

With the failures of the theories that an eastward flowing stream or glacial ice produced the Ontario valley, we are forced, with Upham, Russell and others, to look on a westward flowing stream as the most probable agent in the production of this valley. As has before been shown, such a stream would be the normal result of a gradual development of a drainage system on an ancient coastal plain of the type here considered.

Ancient St Davids gorge. Since the time of Lyell, the old buried channel from the whirlpool to St Davids has played a prominent part in the discussion of the life history of Niagara. For a long time it was considered to be the preglacial channel of Niagara, or its predecessor, the Tonawanda. More recently it has been considered of interglacial age, eroded by an interglacial Niagara, during a temporary recession of the ice sheet from this region, and filled with drift during a readvance of the glacier. The most satisfactory interpretation of this channel however makes it independent of the Niagara, and considers it one of many preglacial or interglacial channels which were formed by streams flowing over the edge of the escarpment and which increased in length by headward gnawing of their waters. This type of stream we have learned to call *obsequent*, its direction of flow being contrary to that of the master stream to which its waters eventually become tributary. An illustration of channel-cutting by streams flowing over the edge of a cliff, may be seen today in the chasm near the Devil's hole, on the American side of the gorge below the whirlpool. This gulch was cut by the little stream known as the Bloody run, which during the summer season dries away entirely.

The St Davids gorge has a width of nearly 2 miles at the edge of the escarpment. As will be seen by a glance at the map, it nar-

[illegible] [illegible]ably southward, till at the whirlpool its width is less than the average width of the Niagara gorge. What the depth of the gorge is has not been determined, though from the depth of the whirlpool we may assume that its floor is 200 feet or more below the level of Lake Ontario. At, and to the north of the escarpment it probably equals in depth Lake Ontario, opposite to it. The channel is undoubtedly much more irregular than is shown on the [illegible] the sides being probably much diversified by lateral gullies. The [illegible] width of the channel at St Davids may perhaps be due [illegible] small degree to widening by glacial erosion; for we know [illegible] the channel was occupied by ice, from the glacial scratches [illegible] preserved on its walls, where these are exposed in the [illegible] of Bowman's creek near the whirlpool. The influence [illegible] buried channel on the direction and width of the Niagara [illegible] will be discussed later.

Valley of Georgian bay. Georgian bay is in many respects the [illegible] of Lake Ontario. Like the latter, it also occupies a valley [illegible] Niagara escarpment and the crystalline old-land [illegible] As has previously been shown, the Niagara es[illegible] northward from Hamilton into the Indian penin[illegible] Georgian bay and Lake Huron, and, after passing the [illegible] reappears in the northwestern face of Grand [illegible] Cabot's head, on the Indian peninsula, the [illegible] feet above the surface of the water, while [illegible] soundings show a depth of 510 feet, thus [illegible] of the escarpment at this point 834 feet. In [illegible] of the escarpment rises to an elevation of [illegible] of more than 1100 feet above Georgian bay [illegible] of the transverse channel connecting Georgian [illegible] has been found to be 306 feet, which is more [illegible] than the depth of the channel of Georgian bay. [illegible] that the soundings do not show the absolute [illegible] bottom in the channel; for there may be a filling [illegible] the bottom of the channel above that of the

The valley of Georgian bay is continued northwestward in the channel known as North passage, a narrow body of water lying between the Manitoulin islands and the Canadian old-land. The southward continuation of the lowland is blocked by drift; but a number of borings, between the southern end of Georgian bay and Lake Ontario, east of Toronto, have developed the existence of a buried channel, which connects these two valleys. This channel is considered by Spencer to mark the pathway of his former Laurentian river. It is clear however that this valley is merely the buried connecting part of the inner lowland which extends along the base of the entire Niagara escarpment. This portion of the lowland was originally occupied by two streams flowing, the one northwesterly into the ancient Saginaw, the other southeasterly into the Dundas. The divide between the two may have been in the neighborhood of Lake Simcoe. It is however not at all improbable that the tributary of the Dundas may have, owing to favorable conditions, gained an advantage over that of the Saginaw, and pushed the divide northward. Such a migration of the divide might have resulted in the diversion of the upper waters of the Saginaw by capture, so that they eventually became tributary to the Dundas. This would account for the greater depth of the Georgian bay lowland, which, after the capture of the upper Saginaw waters, could be deepened independently of the notch in the cuesta through which its waters were formerly carried out. This of course is merely suppositional, and the truth can be established only by more detailed study of the ground. It is however what we might expect to happen in the normal adjustment of a coastal plain drainage. This hypothetic relation is illustrated in fig. 6.

The Huron lowland and the Chippewa and Tonawanda valleys. On the yielding strata of the Salina group a second lowland was carved out by subsequent streams, leaving an escarpment capped by the Devonic limestones on the south. This, as we have seen, becomes prominent eastward in the Helderberg range, where the third upper Devonic escarpment unites with it. In the Niagara region it faces the Tonawanda and Chippewa lowlands, which were probably opened out by a subsequent stream tributary to the ancient Dundas river. Throughout western Ontario this escarpment is buried by drift, but its presence is indicated by borings, which also prove the continuance of the lowland accompanying it. This escarpment, the inface of the second cuesta, becomes a very prominent feature in Lake Huron, where it is entirely submerged. It is however perfectly traceable from north of Goderich in Canada to the island of Mackinaw. Soundings prove it to have a hight of from 350 to 500 feet or more above the lowland which it faces. This lowland constitutes the deeper portions of Lake Huron, the shallower southwestern area being a part of the upland drowned by the backward setting of the water over the top of the escarpment. The following cross-section (fig. 9) from Point au Sable, north of Saginaw bay, to Cape Hurd, the northern extremity of the Indian peninsula, passes across the highest portion of this escarpment at the 9 fathom ledge and diagonally across the deepest portion of the Huron lowland, where the soundings reach a depth of 750 feet. This apparently marks the location of the preglacial Saginaw river, which probably breached the second cuesta to the south of the 9 fathom ledge, though no channel is indicated by the soundings.

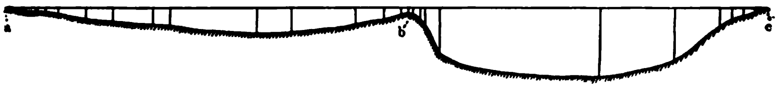
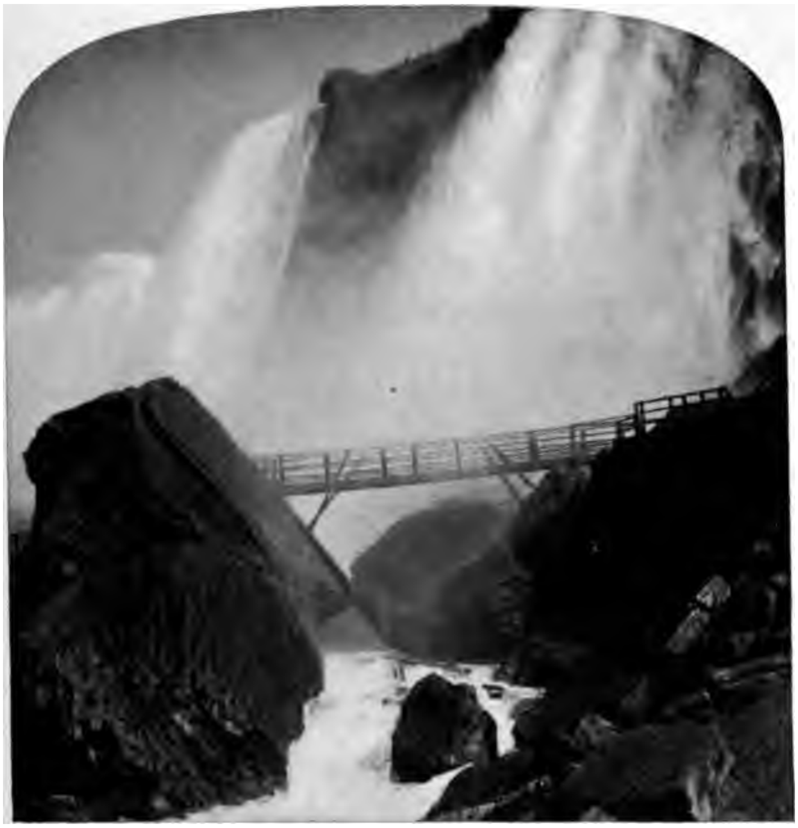


Fig. 9 Section across Lake Huron from Point au Sable, a) across 9 fathom ledge, b) to Cape Hurd, c) (For location of section *see* fig. 6).

We have now traced the development of the topographic features of the Niagara district, and have found this to be in conformity with the laws governing the normal development of drainage systems on an ancient coastal plain. The only abnormal features which need to be considered now are the tilting of the land and the filling of most of the old channels by drift, converting the lowlands into lake basins and reversing the drainage of the unfilled channels. These were the catastrophes which immediately preceded the birth of Niagara and which were directly responsible for its existence. To these and the life history of Niagara, attention will now be invited.

Plate 5



" Rock of Ages ", the largest of the fallen limestone fragments at the foot of Luna falls, on the American side (Copyright by Underwood & Underwood, New York)

UNIV. OF MICH.

Chapter 2

LIFE HISTORY OF NIAGARA FALLS

Glacial period

Two important events immediately preceded the birth of Niagara. The first was the formation of a series of great lowlands and cuestas by stream and atmospheric erosion during a period of time when, according to all indications, the land stood from 2000 to 5000 feet higher than it does now. This was outlined in the preceding chapter. The second event was the accumulation of a great mantle of glacial ice over most of northeastern North America, and the modifications of the previously formed erosion topography, either by the erosive action of the ice or by deposits left on its melting. The time equivalent of the latter event is commonly known as the glacial period of the earth's history, a remote period as time is ordinarily counted, but a very recent one in the chronometry of the geologist. Contemporaneous with this great accumulation of ice was probably the subsidence of the northern part of this region, thus changing the slope of the land surface from a southward to a northward one.

The greatest accumulation of ice during the glacial period appears to have been in the region to the north and northeast of the great lakes, or in general over the area of the Laurentian old-land. The immediate causes which brought about such accumulation, were the extensive refrigeration of the climate and the increased precipitation of moisture, so that a greater amount of snow fell during the winter seasons than could be removed by melting during the succeeding summers. The partial melting and refreezing of the snow, which continued over a long period of time, eventually resulted in producing glacier ice, after the manner of the formation of glaciers at the present time.

The thickness of the great Laurentian glacier, which eventually covered all the land of this region, including even the highest mountains, must be estimated at thousands of feet in its central part with a progressive diminution of thickness toward the margin. The ice of glaciers, as is well known, has a certain amount of plasticity and will flow under the pressure of its own weight, somewhat after the manner of a mass of pitch. The flow of the great Laurentian glacier was outward in all directions from the center of accumulation, local topographic features exerting a deflecting influence only in the more attenuated marginal portions. In its basal portions, the ice was well supplied with rock debris, from the finest rock flour and clay to boulders often of very great size. This material was derived from the surface over which the ice flowed, and it measured in part the amount of erosive work which the ice had accomplished. The rock fragments frozen into the bottom of the moving ice mass, served as efficient tools for grooving and scratching the bedrock over which the ice flowed, while at the same time the finer material smoothed and polished the rock surfaces. The direction of the grooves and striae on the rock surfaces in general indicate the direction of the movement of the ice which produced them, but this may not always represent the direction of general ice movement for the region, since, at the time of making the striae, the ice may have been thin enough to be influenced by the local topographic features of the region. In the Niagara district the striae have a direction extending about 30° west of south (Gilbert) which direction, being inharmonious with the trend of the lowlands, indicates that these striae were formed by the general movement of the ice, rather than by local movements, controlled by topography.[1]

While the surface rocks of this region were everywhere scratched and polished by the ice, these markings are only exhibited where the protecting mantle of loose surface material or drift has been recently removed. For where the polished rock surfaces are exposed for any considerable period of time, weathering usually obliterates these superficial markings. The best place in which the striae of the region about Niagara river may be studied is near the quarries on the edge of the escarpment, a mile or more west of Brock's monument, where the ledges are progressively uncovered previous to quarrying.

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[1] For an account of the glacial sculpture in this region, *see* Gilbert. Bul. geol. soc. Am 1899. 10:121.

Throughout the greater part of the district, the polished rock surfaces are covered by a coating of drift of very varying character and thickness. This was the ground moraine or till of the Laurentian glacier, and represents the rock debris which was frozen into the bottom of the ice, and carried along in its motion, till liberated by the melting of the ice. This ground moraine, either in its original heterogeneous character or modified by the agency of running water, filled most of the old river gorges through which the drainage of preglacial times found its exit. Some of the shallower lowlands, like that of the Tonawanda, were also filled with drift, while the more profound ones, like the Erie and Ontario lowlands, received only a partial drift filling.

The partial obliteration of the old drainage channels, which was thus brought about, together with a depression of the land on the northeast to a depth below that at which it now stands, converted the unfilled lowlands into lake basins, apparently reversed the drainage of many streams, forcing them to cut gorges where their old channels were drift-filled, and finally became the immediate factors in the formation of Niagara.

Lacustrine period[1]

During the slow melting of the glaciers in the Laurentian region, and the resultant northward retreat of the front of the ice, large bodies of water, of varying depth and extent, were held in front of the ice sheet, which formed a dam across the northeastern part of the lowland country, the general slope of which was now toward the ice instead of away from it. The elevations of these glacial lakes were determined by the lowest uncovered passes in the margins of the lake basins across which the discharge took place, and, as during the continued melting of the ice dam, lower passes were progressively uncovered, the outlets were successively transferred to them and the levels of the lakes sank correspondingly.

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[1] For a detailed account of the successive stages in the development of the great lakes, the shore lines, outlets and extent of each, the reader is referred to the papers by Gilbert, Spencer, Taylor, Leverett, Fairchild and others, cited in the appendix.

Though of a temporary nature, these bodies of water endured sufficiently long to permit the formation of well marked beaches with their accompaniment of bars, sand-spits and other wave-formed features. These have been carefully studied and mapped by a number of observers, and the general extent and outline of these lakes is today pretty accurately determined.

The largest of these glacial lakes, though not the first to come into existence was glacial Lake Warren. "At its maximum extent Lake Warren covered the south half of Lake Huron, including Saginaw bay, the whole of Lake Erie and the low ground between it and Lake Huron, extended eastward to within twenty or thirty miles of Syracuse, N. Y. and probably covered some of the western end of Lake Ontario."[1] The retaining ice wall on the east extended in a northwesterly direction, across western New York, Lake Ontario and the northeastern end of Lake Huron. This position of the ice front is in part inferred from the existence of moraines of sand and gravel along a portion of that line. The total area of this ancient lake has been variously estimated as including from one hundred thousand to two hundred thousand square miles of surface but this estimate is based on the assumption that the lake occupied the greater part of the area of the [illegible] upper Great lakes, with the intervening land, a supposition [illegible] holds to be incorrect. The area of Lake Warren [illegible] less than 50,000 square miles, or approximately half [illegible] state of Kansas. The extent and level of this lake was [illegible] there being many oscillations, due chiefly to warpings [illegible] surface. These oscillations are recorded in the various [illegible] which have remained to the present time. The chief outlet [illegible] Warren was by way of the Grand river valley into the [illegible] Lake Michigan, the southern end of which was then much [illegible] and occupied by the waters of "Lake Chicago." The [illegible] of this lake was to the Mississippi by way of the Illinois [illegible] the divide near where Chicago now stands, thus temporarily reestablishing the southward drainage of this region.

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[1] [illegible] short history of the Great lakes, p. 101.

As the ice front continued to melt away, retreating northeastward, drainage at a lower level was permitted along the ice front to the Hudson valley, and the sea. As a result, the water level sank, the Chicago outlet was abandoned, and Lake Warren became much contracted and in part cut up and merged into new bodies of water. The largest of these was glacial Lake Algonquin, which occupied the basins of the three upper Great lakes, and seems to have been for a long time independent of Lake Erie, which after the division of Lake Warren was for a time much smaller than it now is. (Fig. 11 and 13)

The critical period in the development of the lakes, with reference to the birth of Niagara, was the uncovering of the divide at Rome (N. Y.) and the consequent diversion of the drainage into the present Mohawk valley. This brought with it a subsidence of the waters north of the Niagara escarpment to the level of this outlet, which was considerably below that to which the other lakes could subside, owing to the rocky barriers which kept them at greater altitudes. As a result Niagara river came into existence, though at first it was only a connecting strait between Lake Erie and the subsiding predecessor of Lake Ontario. The overflow from Lake Erie occurred at the present site of Blackrock, because there happened to be the lowest point in the margin of the lake. It is not improbable that a small preglacial stream had predetermined this point, either flowing southward into the river occupying the Erie basin, or northward as an obsequent stream into the Tonawanda. The course of the river below Blackrock was determined by the directions of steepest descent of the land surface, which was probably predetermined to some extent by preglacial streams. As soon, however, as the level of the waters of the Ontario valley sank below the edge of the Niagara escarpment at Lewiston, a fall came into existence, which daily increased in hight as the level of the northern lake was lowered. From that time to the present, Niagara has worked at its task of gorge-cutting, the present length of the gorge, from Lewiston to the falls, marking the amount of work accomplished.

When the waters north of the escarpment had subsided to the level of the outlet at Rome, a long period of stability ensued, during which extensive and well marked beaches were formed by the waves. This comparatively long-lived body of water has been named Lake Iroquois, and its outline is shown in the accompanying map (fig. 10) reproduced from Gilbert's *History of the Niagara river*. The Iroquois shore lines in this region may be seen in the ridge road which extends eastward from Lewiston, and westward from Queenston, closely skirting the foot of the escarpment.

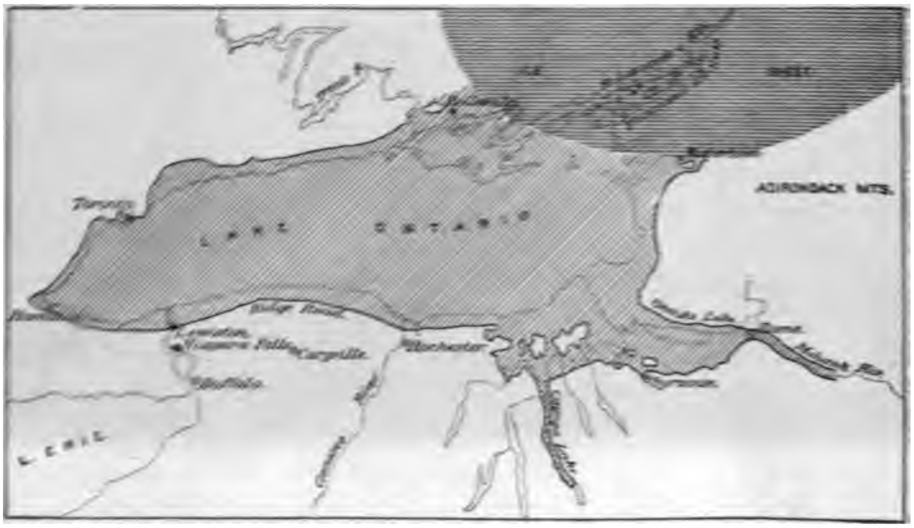

Fig. 10 Map of Lake Iroquois; the modern hydrography shown in dotted lines. (After Gilbert)

A fine section of this old beach is seen just behind the railroad station at Lewiston. Here the layers of sand and gravel slope steeply toward the southeast, and many of them are irregular and wedge-shaped. Some of the beds, a foot or more in thickness, consist entirely of rounded pebbles, with little or no sand between, forming a porous mass of "loose gravel". The prevailing rock of the pebbles is the Medina sandstone, derived from the neighborhood, and the pebbles are always well waterworn, and commonly of the flattened type characteristic of thin bedded rocks. Mingled with the beds of coarse material are layers of fine sand, the structure of which is well brought out by exposure to wind and weather. Not infrequently masses of sand and pebbles are cemented into a conglomerate by calcite or other cementing agents.

The terminal portion of the beach at the Lewiston station is rather exceptional. It has here the character of a sand spit, extending toward the Niagara river. Between this spit and the escarpment there is a low area of irregular outline, something over half a mile in width along the river and extending perhaps three fourths of a mile eastward from it. This area is bounded by steep erosion cliffs of unconsolidated material, and is from 30 to 50 or more feet lower than the level of the ridge road. The suggestion presents itself, that these features may be due to the current of the Niagara at its *embouchure* into Lake Iroquois, at a time when the falls were probably not far distant. (*See* plate 3 and map)

There is evidence that the level of Lake Ontario at one time stood much lower than it does at present; for the bottom of the lower Niagara, from Lewiston to the lake, is from 100 to 200 feet below

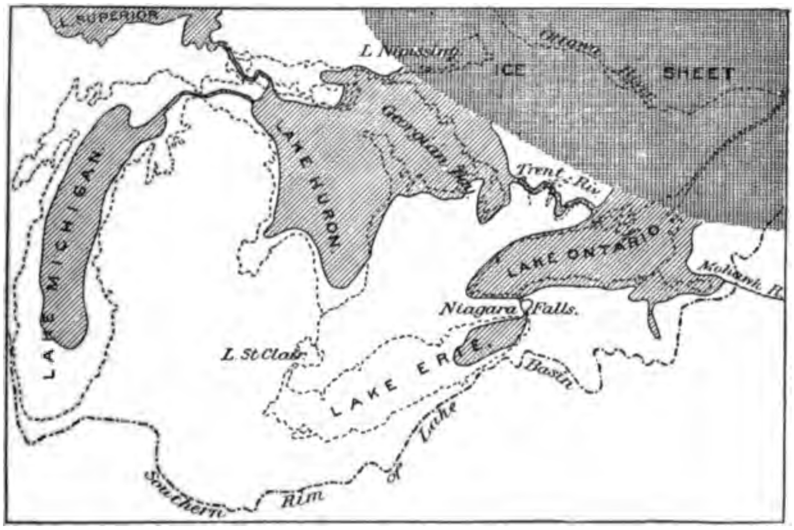

Fig. 11 Gilbert's map of the Great lakes at the time of the Trent river outlet. Modern hydrography dotted.

the present water level. In fact, the old beaches about Lake Ontario indicate a number of oscillations of level, similar to those recorded in the other glacial lakes, and due chiefly to crust warpings.

Lakes Algonquin and Iroquois were probably contemporaneous, and it is believed that for a time the former discharged its waters to the latter by way of Balsam lake and along the course of the Trent river. This discharge by way of the Algonquin river, as this old outlet of Lake Algonquin has been called, robbed the Niagara river of seven eighths of its water supply, which up to then had reached it by the present course through the Detroit river. As a result, the volume and erosive power of the river were for a time enormously diminished. (Fig. 11 and 13)

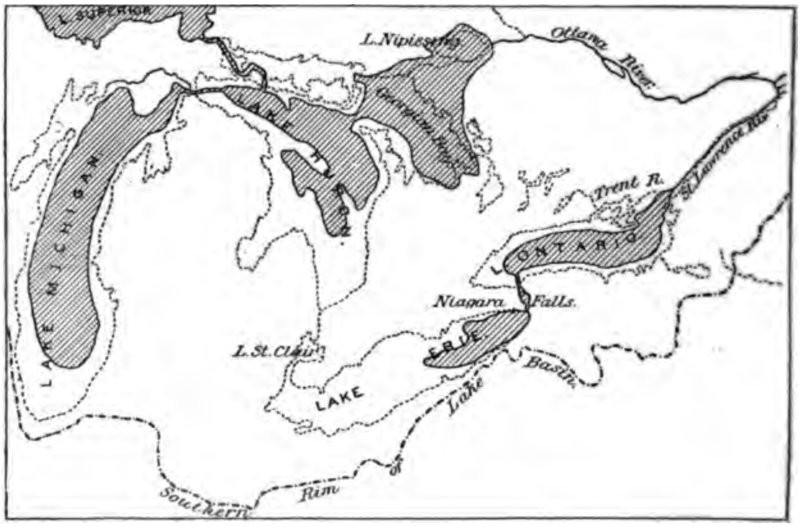

Fig. 12 Gilbert's map of the Great lakes at the time of the Nipissing outlet. Modern hydrography dotted.

During the farther retreat of the ice front, a still lower pass was opened by way of Lake Nipissing and the Mattawa river into the Ottawa. By the time this outlet was opened, the ice had also disappeared from the St Lawrence valley, and the outlet of the waters of the great lakes was transferred from the Rome channel to the one at the Thousand islands, Lake Iroquois at the same time subsiding to Lake Ontario. (Fig. 12 and 14)

The successor of Lake Algonquin, after the change from the Balsam lake to the Nipissing lake outlet, has been named by Taylor, Nipissing great lakes, while the river which carried its discharge to the Ottawa was called by him the Nipissing-Mattawa (fig. 14).

With the gradual melting away of the great ice sheet, the land on the northeast began to recover from its last great depression, and, though there had been many oscillations, the balance of change was toward a slow but steady elevation of the Laurentian region. As a consequence the beaches of the old glacial lakes, which of

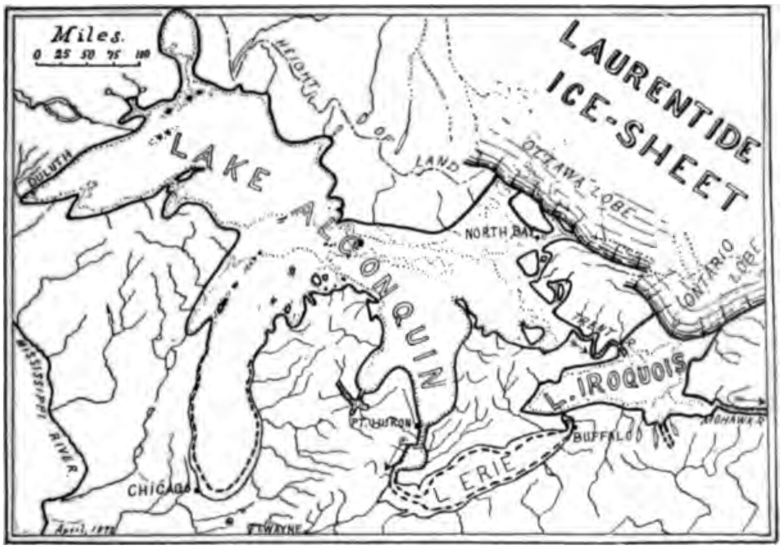

Fig. 13 Taylor's map of Lakes Algonquin and Iroquois.

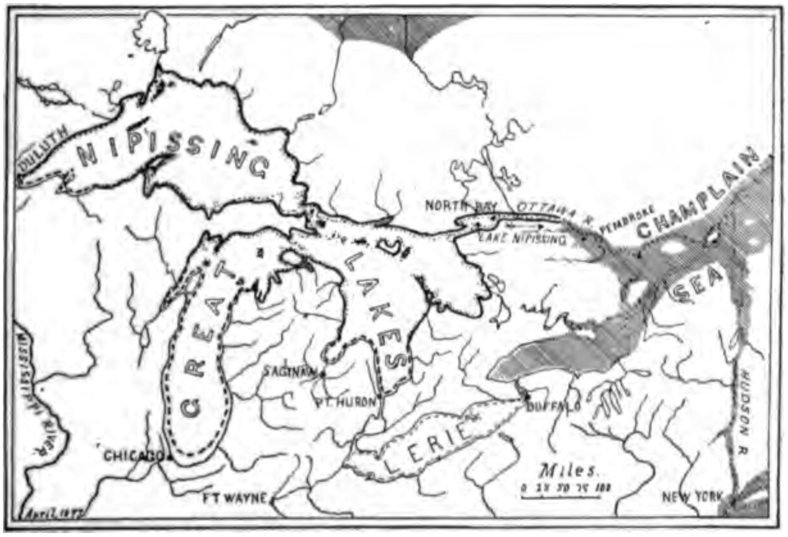

Fig. 14 Taylor's map of Nipissing great lakes and the Champlain submergence.

course had a uniform elevation while forming, are no longer of uniform hight above sealevel, but rise progressively toward the northeast. This slow rising of the land caused a gradual canting of the basins, which brought with it a relative fall of the waters along the northeastern shores and a corresponding relative rise of the waters along the southwestern shores. Such a progressive change eventually carried the Nipissing and Balsam lake outlets above the level of the outlet at Port Huron, and the present drainage was reestablished. As the canting affected the Erie basin as well as the others, it caused a progressive elongation of that lake toward the southwest, thus finally giving it its present size and shape. This same canting also resulted in the farther separation of the upper lakes into their present divisions.

While this general outline of the lake history is held by many geologists, others, notably Upham, combat it strongly. Mr Upham holds that the elevation of the land in the northeast had progressed to such an extent by the time the ice had uncovered the northern outlets of Lakes Algonquin and Nipissing, that these passes had been raised above the altitude of the outlet at Port Huron, and that hence these passes never, or but for a brief period of time, served as outlets for the waters of the upper lakes. If this is the case, Niagara always carried the drainage of the upper great lakes as well as Lake Erie, and its volume was approximately uniform throughout its history. The strong erosion features, however, which are found in the Mattawa valley indicate that a large stream discharged here for a considerable period of time; and, if such was the case, it is highly probable that the present Port Huron outlet was not then utilized, and that consequently the Niagara was robbed of the discharge of the upper lake area. The influence on the erosion of the gorge by such a withdrawal of the water must have been a pronounced one, and we shall see later that certain portions of the gorge may well be explained by this hypothesis. During the time of the overflow of the upper waters by way of the Nipissing-Mattawa river it is not improbable that, as held by Taylor and others, the sea had access to the St Lawrence and Ontario basins and possibly to the basins of the upper lakes. This would account for the occurrence of marine types of organisms in the deeper portions of some of the present great lakes as well as for the maritime species of plants found in the lake district. It must however be borne in mind that this marine invasion was not till after the time of Lake Iroquois, for fresh-water fossils have been found in the beaches of this lake.

The tilting of the land, which is recorded in the deformed beaches, has not yet ceased, as recent investigations in the lake regions clearly prove. Mr Gilbert has made an extended study of this problem; and he has been led to the assumption "that the whole lake region is being lifted on one side or depressed on the other, so that its plane is bodily canted toward the southsouthwest, and that the rate of change is such that the two ends of a line 100 miles long and lying in a southsouthwest direction are relatively displaced .4 of a foot in 100 years". From this it follows that "the waters of each lake are gradually rising on the southern and western shores or falling on the northern or eastern shores, or both". This implies of course a drowning of the lower courses of all streams entering these lakes from the southwest and an extension of those entering from the northeast. Assuming that the rate and character of change will be constant in the future, the following interesting results have been predicted by Mr Gilbert. The waters of Lake Michigan at Chicago are rising at the rate of 9 or 10 inches a century; and "eventually, unless a dam is erected to prevent, Lake Michigan will again overflow to the Illinois river, its discharge occupying the channel carved by the outlet of a Pleistocene glacial lake. . . Evidently the first water to overflow will be that of some high stage of the lake and the discharge may at first be intermittent. Such high water discharge will occur in five hundred or six hundred years. For a mean lake stage such a discharge will begin in about one thousand years, and after one thousand five hundred years there will be no interruption. In about two thousand years the Illinois river and the Niagara will carry equal portions of the surplus water of the great lakes. In two thousand five hundred years the discharge of the Niagara will be intermittent, falling at low stages of the lake, and in three thousand five hundred years there will be no Niagara. The basin of Lake Erie will then be tributary to Lake Huron, the current being reversed in the Detroit and St Clair channels."[1]

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[1] Gilbert, G. K. Recent earth movements in the great lake region. 18th an. rep't U. S. geol. sur. 1896-97. pt 2.

Fluvial period

Niagara falls came into existence when the waters of Lake Iroquois, the predecessor of Lake Ontario, fell beneath the level of the escarpment at Lewiston. At first it was only a small cataract, but day by day, as the lake subsided, it gained in hight and consequently in force of fall, as well as efficiency in cutting its channel. That the entire gorge from Lewiston to the present falls is the product of river erosion is scarcely questioned by any one today, but there are excellent reasons which lead some to believe that this cutting was not wholly the work of the Niagara. When the falls were at Lewiston, the Niagara was a placid stream from Lake Erie to near the falls, much as it is today from Buffalo to the northern end of Grand island. Its banks consisted chiefly of glacial till, into which terraces were cut by the stream, most of which are visible at the present day. The lower ones are well marked in Prospect park, though there they have been grassed over and modified to a considerable extent. From Niagara falls to the railroad bridges at Suspension Bridge, on the New York side of the river, the old bank runs parallel to the edge of the gorge and at a short distance inland from this. From Suspension Bridge to the whirlpool it makes a curve somewhat more crescentic than that of the margin of the gorge, and a similar curve from the whirlpool to Bloody run at the Devil's hole. On the Canadian side these old river banks can be traced from above the falls almost to Brock's monument, and in some cases two or three successive terraces are recognizable. In Queen Victoria park they constitute the steep slope which bounds the park on the west, and parts of which are still actively eroded. Less than a mile below the carriage bridge, the old banks approach close to the modern one and continue, almost coincident with it, to the railway bridges at Clifton. From here to the whirlpool the old river margin has a nearly straight course, while the modern one is curved, and a similar relation holds below the whirlpool, though here, from the great curvature of the modern channel, the old banks are in places nearly a mile distant.[1] (Plate 6)

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[1] These old river banks are indicated on the geologic map by dotted lines; the localities where shells have been found are shown by crosses.

Within the old channel thus outlined, which was much broader than the modern channel below the falls, accumulations of stratified sands and gravels were formed in the more protected places, much as such deposits are formed in streams today, where sands are swept into protected areas. With these sands and gravels were swept together the shells of those mollusks which lived in the river water, and many of which were of the species now found living in the upper Niagara.[1] Most of the shells thus swept together were probably of dead individuals, though living ones may also have been carried into these growing deposits. Many excavations have been made in these ancient deposits, fragments of which are preserved in various places between the former and present banks of the river. The most notable of these and the one longest known is on Goat island, perhaps a quarter of a mile inland from the edge of the cliff, at the Biddle stairway. In the section opened here, most of the material is seen to be coarse and rudely stratified. The pebbles are subangular, often quite angular, while some appear to be scarcely worn at all. Blocks a foot or more in diameter are not infrequent, the material being generally limestone from adjoining ledges, though fragments of sandstone and of crystalline rocks are not uncommon. Occasionally a lens of fine sand occurs which shows cross-bedding structure, the laminae pointing in a northwesterly direction. The shells are found on the cross-bedding planes, conforming with them, and indicating that they were spread there by the current which moved the sand grains. Among the coarse material the shells are mixed indiscriminately. In many cases the gravels are of the loose type, with scarcely any sand between them, indicating deposition by a powerful current. Along these zones air and water have most readily penetrated, and a deposition of iron oxid has been formed which stains both pebbles and shells. The shells are generally very fragile, and commonly show signs of wear. Gastropods are most abundant in the Goat island gravels.

In Prospect park several excavations formerly exposed these gravels. The deposit here consists of sand and gravel with the pebbles moderately rounded, though occasionally subangular, and

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[1] For descriptions and illustrations of these shells, *see* chapter 5.

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In Prospect park several excavations formerly exposed these gravels. The deposit here consists of sand and gravel with the pebbles moderately rounded, though occasionally subangular, and varying in diameter up to 6 inches or a foot. The stratification is rude, and shells are abundant. These are mostly fresh-water mussels (Unio, Alasmodonta, etc.) and the valves are generally found in conjunction, a fact which may indicate that these shells lived here. Small gastropod and pelecypod shells are plentifully mingled with the pebbles and sands. Below this are coarser deposits where boulders up to several feet in diameter occur, and below this occurs a bluish clay. In all of these beds shells have been sparingly found.

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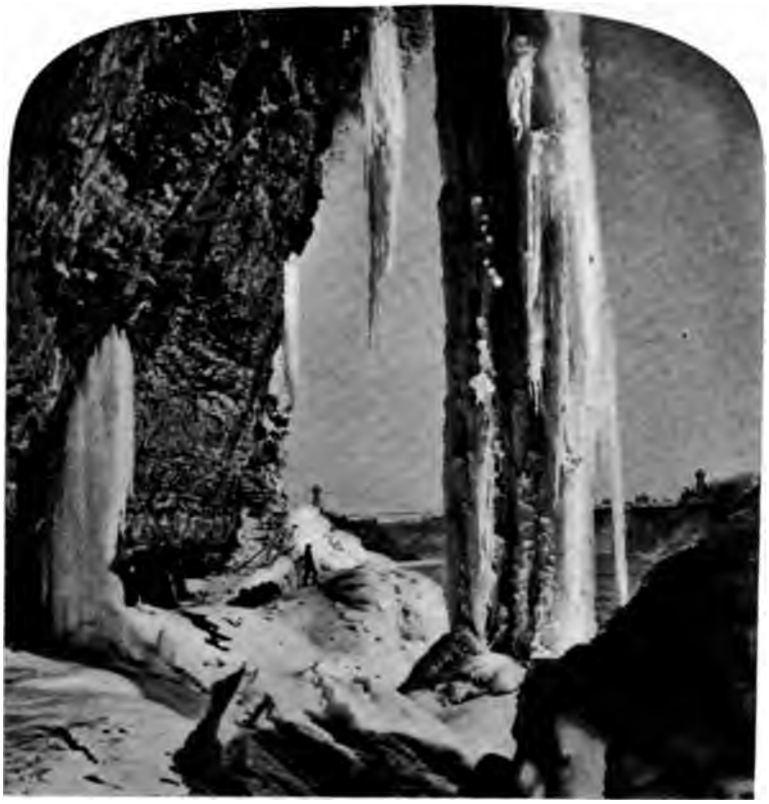
[1] For descriptions and illustrations of these shells, *see* chapter 5.

Several excavations have been made in Queen Victoria park, and here shells are common. The Unionidae appear to be most abundant, though small gastropods are not uncommon. All appear to have been more or less waterworn. The mussel shells are generally decayed, owing no doubt to percolating waters. Below Clifton, the lower of two terraces is of a somewhat sandy character, though many boulders occur in it. Shells of unios occur sparingly in these deposits, and a few small gastropods were found in the lowest terrace. Farther north several excavations in the lower terraces of the old river show loose gravels alternating with a sort of till, a few Goniobasis and other gastropod shells being found here. In some cases the gravels have become cemented into a conglomerate by a deposit of calcite between them, often of considerable thickness. Boulders of similarly cemented gravels are found in the gorge below, at the whirlpool.

It will thus be seen that, throughout the greater part of the young Niagara, deposition was going on as well as erosion. The amount of erosion of the river bed was probably very slight, that of the banks being much more pronounced. The chief part in the cutting of the gorge was enacted by the cataract, which cut *backward* from Lewiston, the amount of *downward* cutting by the river being insignificant. The manner in which the cataract performed its work of cutting may today be observed in both the American and Canadian falls, as well as in waterfalls of other streams falling over strata, the arrangement of which is similar to that obtaining at Niagara. The essentials are a resistant stratum overlying a weak one, the latter being constantly

Plate 7



Cliff on the Canadian side of the gorge, showing the receding base. The giant icicle marks the edge of the overhanging ledge (Copyright by Underwood & Underwood, New York)

worn away by the spray generated by the falling water, thus undermining the resistant layer. Such undermining may be seen in the Cave of the Winds. In course of time this undermining progresses so far that the projecting portion of the capping stratum breaks down for want of support, and the crest line of the fall becomes abruptly altered. The fallen fragments accumulate at the foot of the fall, where they will remain if the force of the water is unable to move them, as illustrated by the rock masses lying at the foot of the American fall. If, however, the force of the falling water is great as at the Horseshoe falls, these blocks will be moved about, perhaps even spun about, and so made to dig a deep channel below the falls. In the soft rocks which lie at the foot of the Horseshoe falls a channel probably not less than 200 feet in depth has been dug in this manner. (Fig. 15)

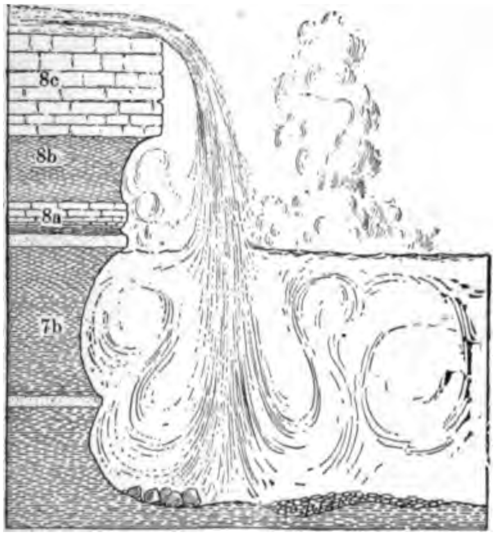


Fig. 15 Sectional view of the Horseshoe falls showing arrangement of strata, and depth of water below falls. (After Gilbert) The numbering of beds corresponds with that of table.

When we consider the Niagara gorge in detail we find it to be much more complex than would at first appear. The first abnormal feature which presents itself in a map view of the entire gorge is the bi-crescentic character of its course, with the rectangular turn at the whirlpool, a course very different from that which we are accustomed to find in large rivers whose direction of flow has been [illegible] by preexisting relief features (Fig. 16). Another feature of importance is the varying width of different parts of the gorge and the corresponding increase in velocity of current in the narrower parts. The depth of the channel also varies in different portions of the gorge, being in general greater in the wider and less in the narrower parts (Fig. 18).

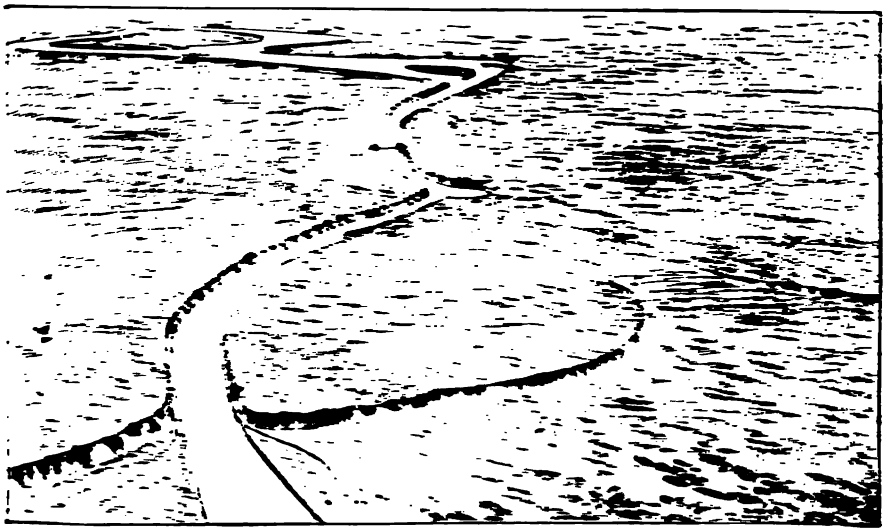


Fig. 17 Bird's-eye view of Niagara gorge showing the course of the river, the falls, the railroad bridges, whirlpool, location of Foster flats, escarpment at Queenston and flaring mouth of old St Davids gorge. After Gilbert.

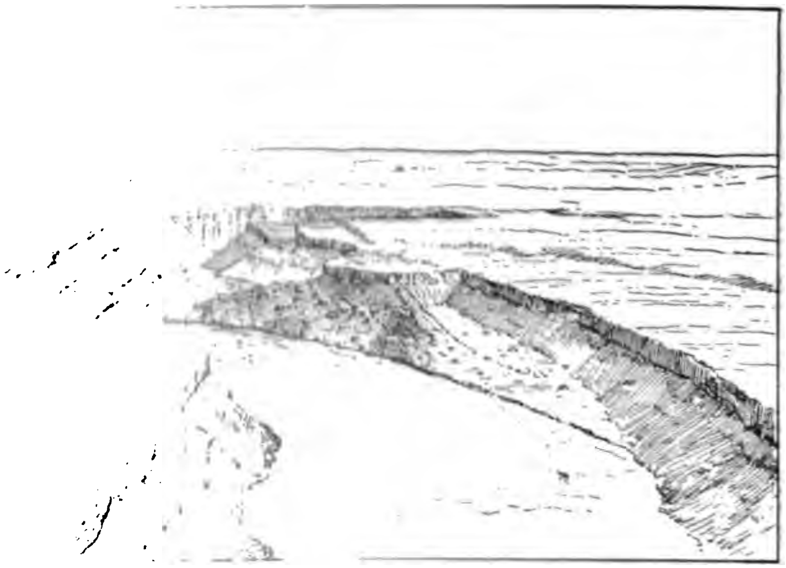
The first mile and three fourths of the gorge, or that portion marking the retreat from the escarpment to the Devil's hole, extends nearly due south and is fairly uniform in width, comparatively narrow, and with a current of great velocity. The narrowness of this stretch, when compared with the channel made by the present cataract from the railroad bridges southward, seems to indicate a smaller volume of water during its formation than that now passing over the falls. An alternative hypothesis accounts for the narrowness of this section of the gorge by assuming it to be a preglacial drift-filled channel made by an obsequent stream flowing northward to the Ontario lowland, similar to that which made the old St Davids channel, but reexcavated by the Niagara. It is highly probable that there was at least a shallow channel which served as a guide to the young Niagara. The southward continuation of this channel beyond the Devil's hole, is found in the valley of Bloody run, a shallow but distinct depression now followed in part by the Lewiston branch of the New York Central railroad and evidently of preglacial origin, as its floor is covered with till.

Next above this lowest section of the gorge is one, in general much broader, and extending in a southwest direction from the Devil's hole to the whirlpool, a distance of a little less than two miles. This section is contracted near its middle by the projection from the Canadian bank, known as Fosters flats, or Niagara glen. The river is here scarcely 300 feet wide, though the tops of the banks are in places over 1700 feet apart. Above Fosters flats and almost as far as the whirlpool, the river is very calm, and apparently deep, while at the point of contraction at the southern end of Fosters flats, the waters suddenly become tumultuous and rush through the narrow channel with great velocity. This sudden change has been attributed to a sudden decrease in depth of the river at this point, but it is evident that, even if the channel had the same depth as above, the sudden contraction would produce a similar effect, for the waters, spread out over a broad and deep channel, on being suddenly forced to pass through a narrow one, would from mere crowding into a smaller space assume a violent aspect.

Niagara glen, or Foster's flats

PLATE 8

This is one of the most interesting places along the whole Niagara river, though generally little visited by tourists. From the Canadian side a platform of limestone projects, whose surface is a little below that of the general level of the upland plain, from which it is separated by a steep bluff. The platform is known as Wintergreen flat, and, though sparingly wooded, is very deficient in soil. The bluff which bounds it on the west is a part of the old river bank. On the remaining sides this platform is limited by abruptly descending cliffs, at the base of which are extensive talus slopes descending to a lowland of considerable extent. This lowland, which is known as Fosters flats, has its surface well strewn [illegible] of limestone. The cliff which limits Winter- [illegible] northern or downstream side is the highest and [illegible], and from its base a well marked, dry channel [illegible] a third of a mile to the river's edge. This chan- [illegible] from the present river channel on the right by a [illegible] to consist of huge limestone blocks, though its [illegible] formed by undisturbed remnants of the lower [illegible] The floor of this old channel is strewn with [illegible] boulders, such as are found at the foot of the [illegible], and its left bank is the precipitous west wall [illegible] gorge (Fig. 17)



[illegible] looking south. Forests omitted. **(After Gilbert)**

[illegible] have been well explained by Mr Gilbert.[1] [illegible] island comparable to Goat island, divided [illegible] had receded to the northern end of Fosters [illegible] of this island, which has since crumbled [illegible] ridge which divides the old dry channel on [illegible] floor of the river. The eastern or American [illegible] the larger of the two, and it receded more

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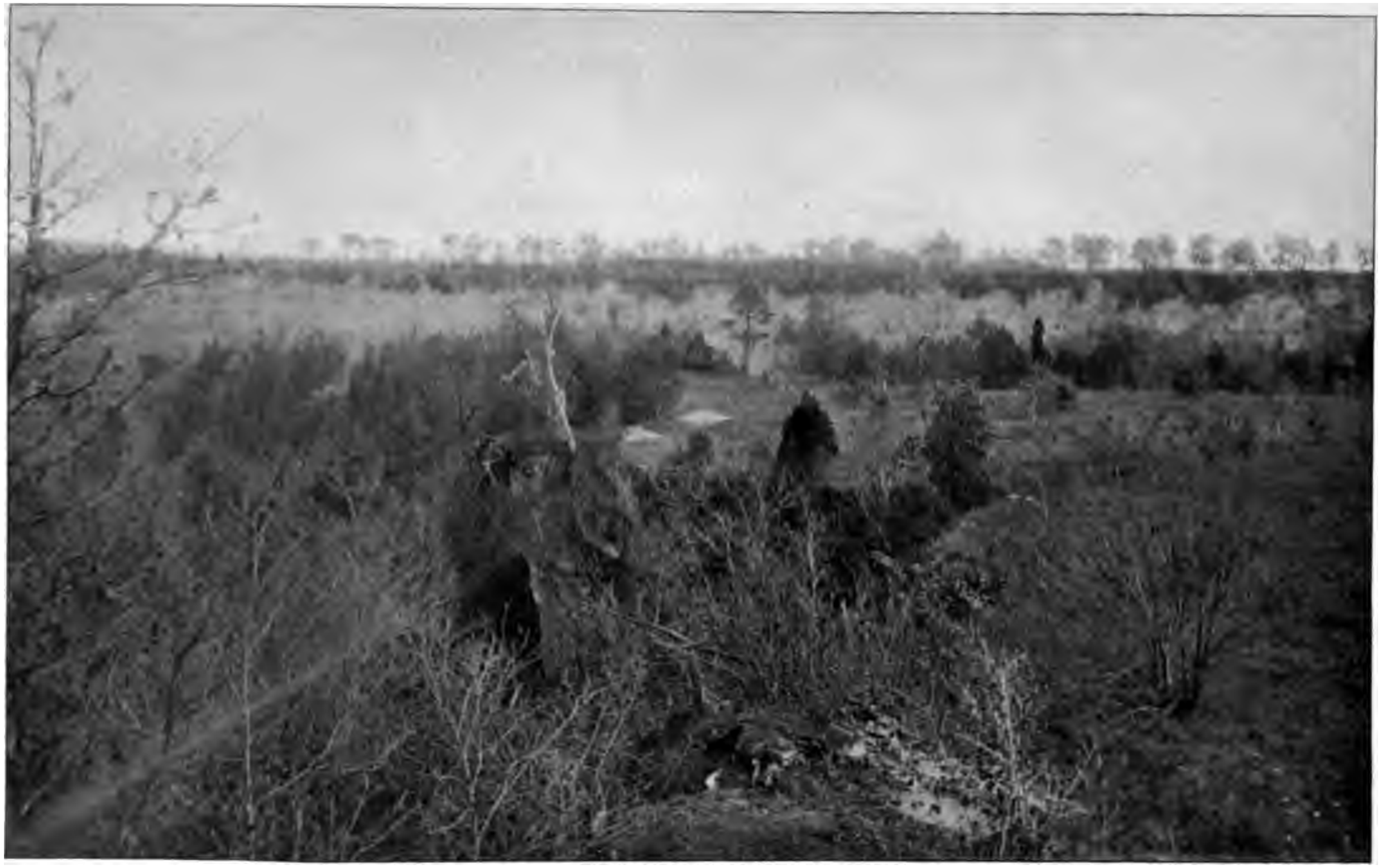
[1] [illegible] Niagara falls and their history.



Wintergreen Flat looking south; showing the platform which was formerly the river-bed, and the cliff in the center which was once the site of a fall

rapidly. " When the Canadian fall reached the head of the island, the American had just passed it, and part of the sheet of water on Wintergreen flat was drained eastward into the gorge opened by the American fall. The Canadian fall, through the loss of this water, became less active, and soon fell out of the race."[1] By the final retreat of the American fall beyond the southern end of Wintergreen flat, the latter was left as a dry platform with precipitous sides, over which once poured a portion of Niagara's torrent.

While the occurrence of an island in the position pointed out by Gilbert was undoubtedly the immediate cause of the division of the falls, the more fundamental cause, and the one to which the island itself owed its existence, is to be sought elsewhere. From an inspection of the map the suggestion presents itself that there may be a vital connection between the abandoned falls at Fosters flats and the great bend of the river at the whirlpool. When a great river runs for a mile or more in a straight line, as the Niagara does above the whirlpool, and then abruptly turns to the right, the current is deflected by this sudden change in direction to the right bank of the river below the bend, which it continues to hug till again deflected. It is thus that the greatest amount of water will be carried along the right bank of the river, causing a deeper channeling there. When Niagara falls had receded to the present northern end of Foster's flats, the greatest amount of water was carried over its right side. The resulting deepening of the channel on the right, and the consequent drawing off of the water toward that side, was the cause of the appearance of the island (if such existed, as seems probable from the remaining foundation) above the water and the consequent division of the falls. A precisely analogous feature occurs in the lower falls of the Genesee river below Portage. Here, however, no island was formed, though in other respects the two cases are nearly alike. In the Genesee the change has occurred in comparatively recent times, and records of earlier conditions have been preserved. An abrupt bend of the river to the right, deflected the current to the right bank below the bend, and thus caused the deepening of the river bed on that side, as well as the more rapid recession of the right hand portion of the falls. In the course of a comparatively short time the channel became so deep on the right, and the falls receded so fast on that side, that all the water was drawn off from the larger portion of the river bed on the left, which today remains as a triangular platform comparable to Wintergreen flat, with steep sides, and several hundred feet wide, at its downstream end. The river now flows in a channel, in places less than 10 feet wide, and 100 feet below the level of the platform which was its bed less than 100 years ago. The present lower fall, having mostly receded beyond the upstream end of the platform, again extends across the entire bed of the river. The water in the river has not, as far as known, changed in average volume, though above and below the narrow part the gorge is many times as wide. All the water which passes in a thin sheet over a broad fall above the narrow gorge is forced to pass through this contracted portion, and presents a rushing current, though the bed is deeper here than where the gorge is broader. The time required for the recession of the fall over the space of the 2000 feet of narrow gorge, must have been much shorter than that required for the recession through a similar length in the broader portion of the gorge, for the concentration of the waters here enabled it to do much more effective work.

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[1] Gilbert. Nat. geog. monographs. Niagara falls and their history.

Judging by analogy, we may assume that the narrow channel opposite Foster's flats was cut by a stream of the full power of the present Niagara, but whose main mass of waters was carried over the right side of the fall on account of the bend in the stream above. The present Horseshoe falls is cutting a much narrower gorge than that to the north of it, owing to its peculiar position at the angle of a second great bend. (Fig. 19) From the fact that the cutting was most profound on the eastern or right bank of the river at Foster's flats, this bank has received the precipitous character which it has retained to the present day.

An interesting fact bearing on the interpretation of the history of Foster's flats, is the occurrence in the sands among the huge boulders near the foot of the ancient falls, of shells of the small fresh-water gastropod, Pomatiopsis lapidaria Say.[1]

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[1] *See* chapter 5.

which is found living in the Niagara river today, but only on the rocks and boulders lying in the constant spray of the modern cataract.

After passing Foster's flats, the scene of greatest erosive activity seems to have been transferred to the left bank of the river. This is indicated by the verticality of this side of the gorge south of Foster's flats, which suggests active erosion, while the lowland known as Ongiara park opposite to this on the New York side of the river, with its enormous boulders scattered about, recalls the dry channel on Fosters flats or the foot of the present American fall, and suggests an amount of water insufficient to remove them. This may be accounted for by assuming that the nearness of the fall had given the river itself greater momentum above the fall, and that hence it dug deeper into the old drift-filled valley of the St Davids at the whirlpool. As a result, the deflection of the current to the right bank became more abrupt, striking the New York bank immediately south of where Ongiara park now is, and, being again deflected toward the Canadian side, it reached this just at the southern end of Foster's flats, thenceforth for a time causing the most active erosion on that side. The washing out of the drift from the old St David's channel furnished the river with tools with which it was able to cut down into its bed, so that in this portion erosion was probably both by backward cutting of the falls and downward cutting of the river above the falls.

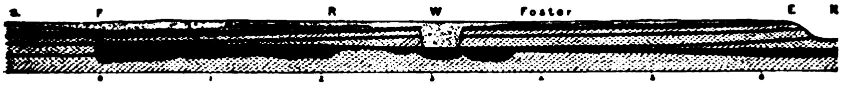

Fig. 18 Longitudinal section of the Niagara gorge from the falls F to Queenston hights E, showing strata of west bank and depth of channel. (After Gilbert) R railway bridges. W whirlpool. Foster = Foster's flats. Figures indicate miles.

We have so far considered the falls as of simple type, but it is by no means certain that such was the case. If we judged from analogy with other streams which have cut gorges in the same strata as those found at Niagara, we should suppose that, as in the case of these streams, a separate fall was caused at Niagara by each resistant layer. Thus in the lower Genesee river, at Rochester, one fall is caused by the upper hard bed of the Medina formation, another by the limestone of the Clinton group, and a third by the Lockport limestone. In the Niagara river we might suppose that at least three, and possibly four, falls had existed at one time. The lowest of these would have been over a hard bed of sandstone, about 25 feet thick, and about 100 feet below the top of the Medina group. Another might have been caused by the hard capping stratum of Medina sandstone, 10 feet thick. A third over the 30 feet of Clinton limestone; while a fourth would have been formed over the Lockport limestone. The second and third would perhaps unite in one, as the shale bed between the two resistant layers is only 6 feet thick. It may however be objected that in a great cataract the force of the falling water is such as to cause uniform recession of all the layers, and that hence only one great fall existed.

The whirlpool

PLATE 9

Perhaps the most remarkable part of the entire gorge is its great swollen elbow, the whirlpool. Here the current rushing in from the southeast with great velocity, circles around the basin and finally escapes, by passing under the incoming current, through the comparatively narrow outlet, in a northeasterly direction. The waters in the whirlpool have probably a depth of 150 or 200 feet, but both the outlet and the inlet are shallow, for here ledges of the hard quartzose bed of the Medina formation project into the river, extending in the latter case probably across the channel. An examination of the walls of the whirlpool basin shows that rock is absent on its northwestern side, the wall here being formed of unconsolidated material or drift. This is best seen on descending to the edge of the whirlpool on the Canadian side, through the ravine of Bowmans creek. It will be observed that the Niagara has here exposed a cross-section of the ancient drift-filled channel which extends southeastward from St Davids. This channel appears to have
en that of a preglacial stream of the obsequent type,[1] which was
tary to the streams of the Ontario lowland. Some geologists
ver, notably Mr Taylor, believe that this old channel may have

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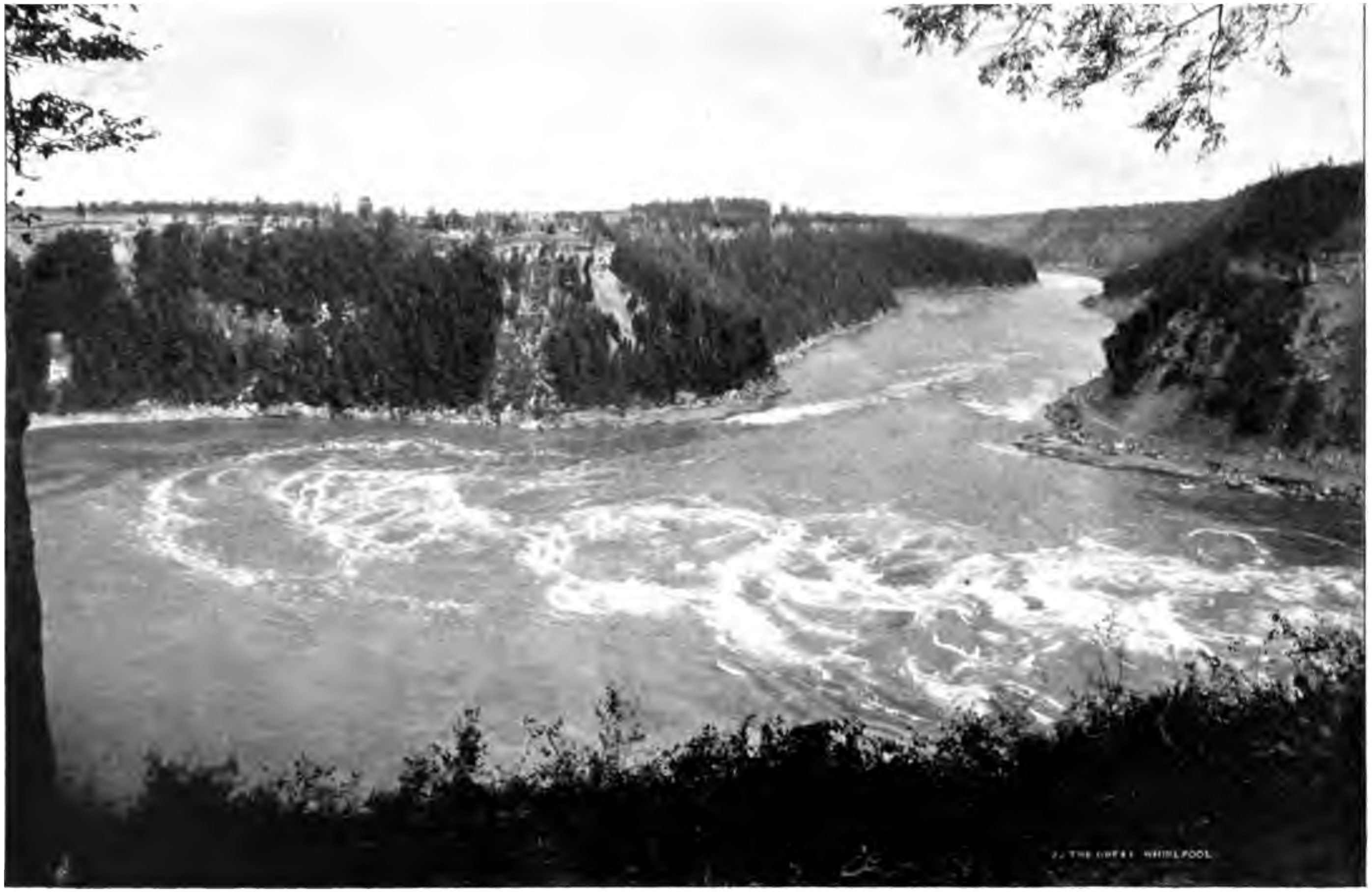
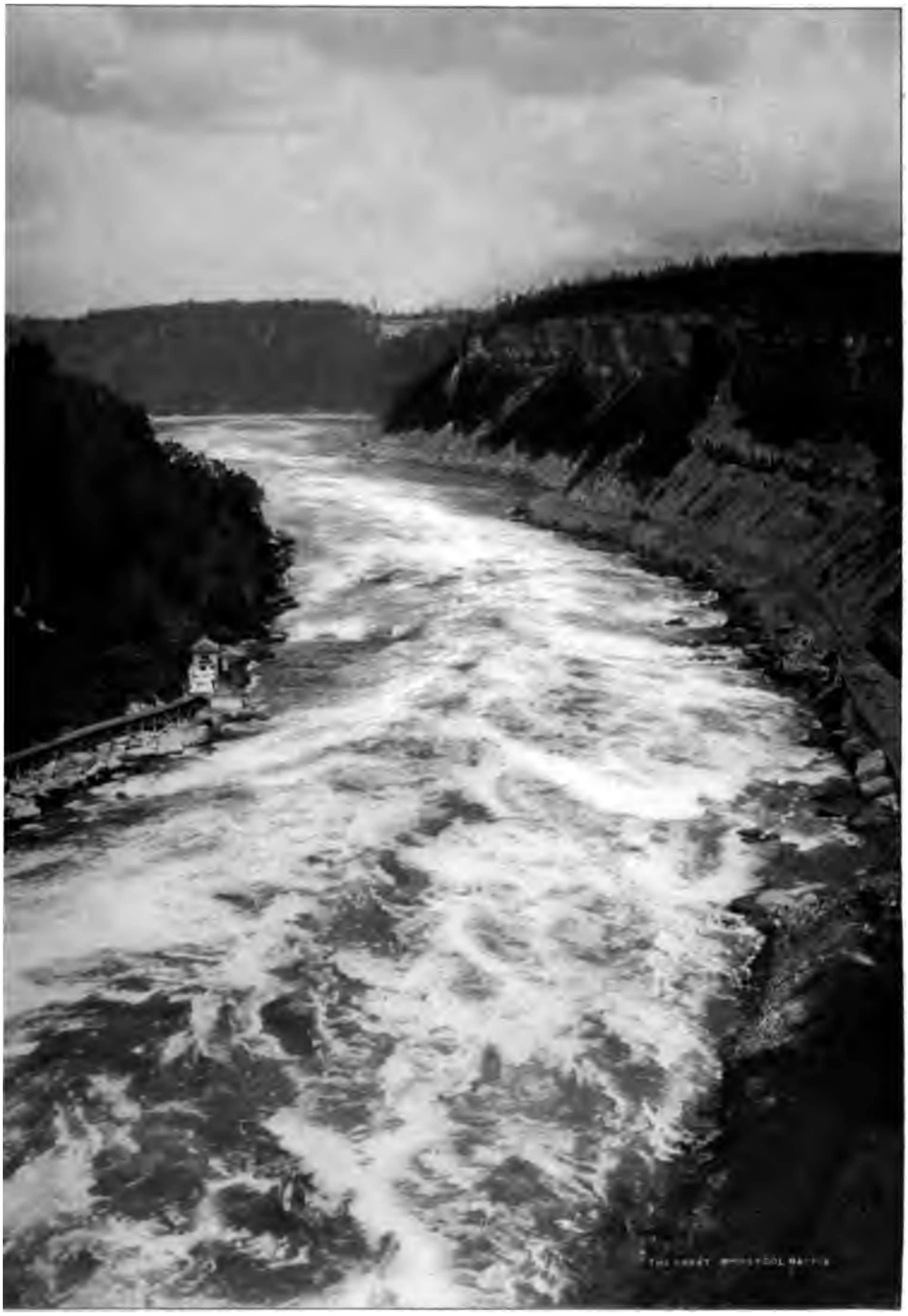


[illegible] from the Canadian side. The ledges projecting at the water's edge, at the outlet, are the gray band of the Medina

been formed by a river and cataract similar to the Niagara of today, during interglacial time. That this old channel was once occupied by ice is shown by the glacial scratches on the limestone ledges exposed in the western wall of the old gorge, where this has been cleared of drift by Bowmans creek, and it is apparent that the filling in by drift must have occurred after the ice occupation. An inspection of the map will show that a part of the present Niagara gorge, that containing the whirlpool rapids, is in direct continuation of the old St Davids channel, and that, a little above the railroad bridges, the Niagara makes a pronounced bend, which brings it in conformity with the direction of this channel. This suggests that there was at least a shallow depression, the insignificant southeastward continuation of the St Davids channel, which guided the waters of the Niagara in this direction. Here a question of great importance in the history of the Niagara presents itself. Did the ancient St Davids gorge end where is now the south side of the whirlpool, with only a shallow surface channel extending beyond this point, or was the gorge of the whirlpool rapids a part of the old St Davids channel, which was merely cleared by the Niagara of the drift that filled it? The latter condition was assumed to be the true one by Dr Julius Pohlman of Buffalo, a pioneer in the study of the Niagara gorge and the first to recognize the complexity of the channel and attempt to account for its varying character. The theory is still held by many geologists. On the other hand, Taylor and others think it more likely that the ancient gorge stopped where is now the inlet to the whirlpool, and that the gorge above it is the product of post-glacial erosion. If this view be accepted, the narrowness and shallowness of the gorge of the whirlpool rapids must be accounted for by some change in the volume of water during its formation. Taylor, who has studied this problem, has come to the conclusion that, during the time that the gorge of the whirlpool rapids was being excavated, the upper great lakes (then united into Lake Nipissing) discharged by way of the Nipissing-Mattawa river as already outlined, and that therefore Niagara drained only the shallow Lake Erie, the amount of water in the river being only one eighth its present volume. It is easy to see that such a reduction in volume would lead to a great decrease in cutting power, and that the resultant gorge would hence be much narrower and shallower than the one cut when the water supply was as large as at present. The Nipissing-Mattawa outlet was finally closed, as we have seen, by the elevation of the land on the north, and the upper lakes assumed their modern outlet by way of Port Huron. As a result the water supply of Niagara was greatly increased, and the broad and deep gorge, which extends from south of the railway bridges to the present falls, was cut by a cataract of the size of the present Horseshoe falls, which in addition carried the water now passing over the American falls. This correlation between change in drainage of the upper lakes and change in size of the gorge of Niagara is certainly very suggestive, and seems admirably to account for many features observed in the gorge. For example, it explains satisfactorily the sudden widening of the gorge just before reaching the whirlpool, forming what Taylor has called the Eddy basin, from the strong eddy which characterizes this portion of the river. This wider part of the gorge Taylor believes was formed by the same large-volume river which cut out the broad channel north of the whirlpool, and he farther thinks, that the sudden change from this broad channel to the narrow one of the whirlpool rapids marks the reduction in volume of water on the opening of the Nipissing-Mattawa channel, which had hitherto been blocked by the remnant of the Laurentian glacier. There are however several features which must be satisfactorily explained before this theory (which Upham rejects on grounds already stated) can be accepted. It is highly probable that the gorge of St Davids was worn back beyond the whirlpool. From the great depth of the whirlpool basin, and the presence of the quartzose sandstone bed at the inlet to it, it seems probable that a fall existed here in the ancient stream which carved the St Davids channel. That channel has probably a depth similar to or greater than that of the part now constituting the whirlpool basin. Now, if, as we have reason to believe, this old channel was formed by an obsequent stream of moderate volume flowing northward to the Ontario lowland, it can hardly be assumed that there was but one continuous fall of from four hundred to five

Plate 10



The Whirlpool rapids and American bank, looking north. The talus above the gorge road covers the **upper Medina sandstones and** shales. The lowest projecting ledge consists of the two Clinton limestones; **the talus above that** covers the Rochester shales, and the upper cliff is of Lockport limestone. **The upper gray Medina** projects in one place, and shows the Clinton shale above it

hundred feet in hight, with such a pronounced alternation of hard and soft layers. We must rather assume that a separate fall existed over each hard layer, and that, as in the other streams flowing northward over these same strata, these falls were separated from one another by considerable distances. If then, as is clearly indicated by the quartzose sandstone ledge at the inlet to the whirlpool, the lowest of these falls was at that place, the other two or three must have been at some distances up stream, and in that case it is not too much to assume with Pohlman, that the upper old falls over the Lockport limestone were somewhere near where the gorge is now spanned by the railway bridges. Taylor, however, does not encounter this difficulty, for he assumes that the St Davids gorge was formed by an interglacial Niagara, the great cataract of which, just before its cessation (probably through a southward diversion of the drainage) plunged as a single fall over the cliff into the basin now holding the whirlpool. To this view it may be objected that the old St Davids gorge is not such as would be formed by a single great cataract, since it flares out northward, having a width at St Davids of perhaps two miles. Such a form is more readily accounted for if one assumes that the valley was made by the headward gnawing of an obsequent stream and its various branches. Taylor meets this objection by invoking the action of readvancing ice to broaden the gorge, but, unless the last ice advance was from a very different direction from that indicated by the striae of this region, this hypothesis will scarcely hold. That direction, as already noted, is 30° west of south, while the direction of the old gorge is almost due northwest. Why may we not assume that only a portion, the southern one of the gorge of the whirlpool rapids, was carved by the Niagara during the time that its volume was diminished, and that the greater portion of this gorge was preglacial? This would greatly reduce the length of time during which the upper lakes discharged by way of the Nipissing-Mattawa river, though probably leaving time enough for the waters from these lakes to produce all the erosion features found in this ancient stream channel. This would still leave the Eddy basin to be accounted for, a difficulty which may perhaps be diminished by assuming that the second of the ancient falls was situated at the point where the gorge contracts to the width of the narrower channel of the whirlpool rapids.

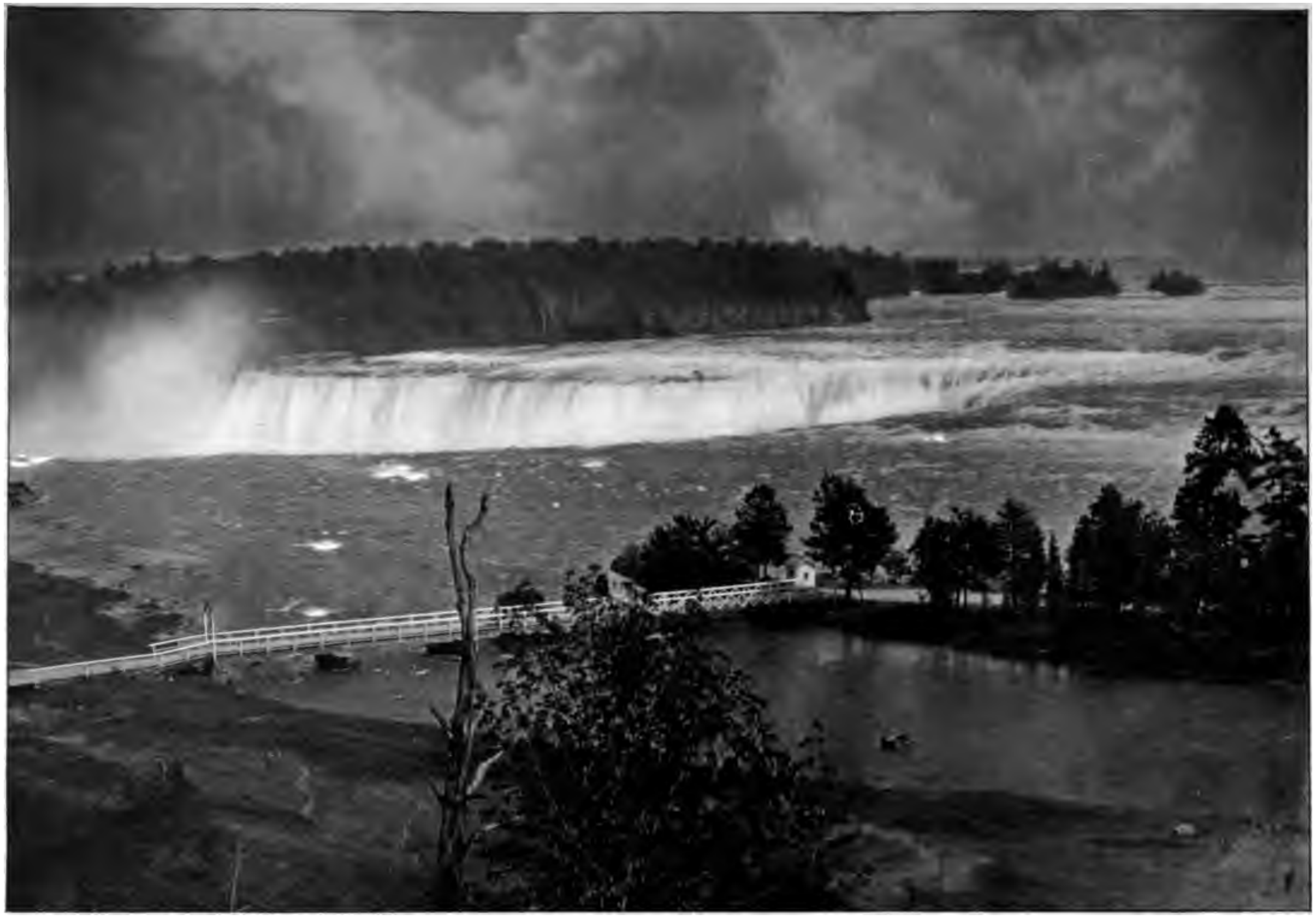
It will thus be seen that this interesting problem of the origin of the gorge of the whirlpool rapids, propounded nearly 20 years ago by Dr Pohlman, is by no means wholly solved. We may return to the original solution of the propounder of the question or we may find new evidence which will corroborate Taylor's explanation. And who shall say that still other explanations of these features may not be forthcoming in the future, when those now demanding attention will be no longer regarded as plausible or sufficient?

The upper gorge and the falls

PLATES 1, 2, 4, 5, 11

Whatever may be believed with reference to the narrow gorge of the whirlpool rapids, most observers agree that the broad and deep gorge from Clifton to the present falls was made by a cataract carrying the full supply of water. This, the latest and most readily interpreted part of the gorge, has come to an end at the Horseshoe falls of today, and the character of the channel hereafter to be made can only be conjectured. The river has reached another of its critical points, where a rectangular turn is made, and it is not improbable that [illegible] the character of the gorge will [illegible] narrower than that [illegible] the Horseshoe [illegible] channel is due to the [illegible] It is easy to [illegible] resistance to this [illegible] shown by the [illegible] The channel above [illegible] feet below the [illegible] in the island [illegible]

[illegible] and rushing waters [illegible], from which it is [illegible] this deepen[illegible] in the cur-



The Horseshoe falls with Goat island and the Three Sisters, as seen from the Canadian side. This view illustrates the narrowness of the gorge now forming.

rents may be seen from the upper walks in the Canadian park, and the effectual erosion of the banks may also be observed. In many cases the shores have been ballasted and otherwise protected against the current. During an earlier period, when the falls were situated farther north, and before the central part of the stream had been deepened to its present extent, the water, then at the level of the river above Goat island, flooded what is now the Queen Victoria park, and carved from the till the pronounced concave wall which now bounds the park on the west. A local eddy, probably during very recent times, carved the steep and still fresh semicircular cliff which incloses the Dufferin islands.

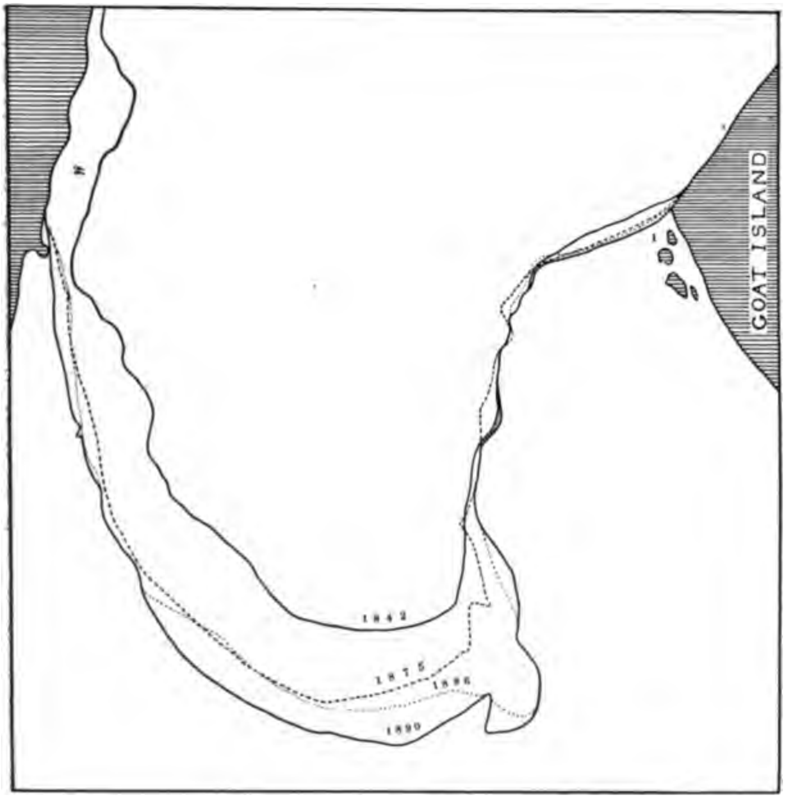


Fig. 19 Crest lines of Horseshoe falls. From the original tracing of the surveys by courtesy of the New York state engineer and surveyor. 1 Terrapin rocks. 2 Former Table rock.

The fate of Goat island is not difficult to foresee. In a thousand years from now, at the present rate of recession, the Horseshoe falls will have reached the upper end of the island and will draw off all the waters from the American falls, which by that time will have receded only about half way to the Goat island bridge. All the islands will then be joined by a dry channel to the mainland, an event which was anticipated in the year 1848, when, owing to an ice blockade in the Niagara river near Buffalo, the American fall was deprived of all its waters for a day. As already indicated by Gilbert's forecast, in from two to three thousand years from now, or long before the falls have even reached the head of Grand island, the drainage of the great lakes will be reversed, provided the land continues to rise northward as it has in the past, and Niagara will carry only the drainage of the immediate neighborhood. From a majestic cataract it will dwindle to a few threads of water falling over the great precipice, such as may be seen during the summer season in the upper falls of the Genesee at Rochester.

Age of Niagara

Speculations as to the age of Niagara have been indulged in ever since men began to recognize that the river had carved its own channel. The length of time required for the excavation of Niagara gorge is not merely of local interest but serves as a basis for estimating the length of time since the disappearance of the Laurentian glaciers from this region, and incidentally it has served as a chronometer for approximately measuring the age of the human race on this continent. From insufficient data Sir Charles Lyell estimated the age of Niagara at 36,000 years, while others have assumed an age as high as 100,000 years or more.

No reliable basis for estimating the age of the gorge was known till a series of surveys were made to determine the actual recession of the cataracts. From these the following variable rates of recession of the two falls have been obtained.[1]

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[1] Report N. Y. state engineer. 1890.

The American falls

	Feet a year
From 1842 to 1875	.74
1875 " 1886	.11
1886 " 1890	1.65
averaging	
From 1842 to 1890	.64

The Horseshoe falls

	Feet a year
From 1842 to 1875	2.01
1875 " 1886	1.86
1886 " 1890	5.01
averaging	
From 1842 to 1890	2.18

This shows a most rapid increase in the rate of recession during the four years between the last two surveys. From this we may assume that the mean recession of a cataract combining the volumes of both American and Horseshoe falls, such as existed throughout the greater period of gorge excavation, is at least three feet a year and may be as high as four or even five feet a year.

The first to make use of this known rate of recession in estimating the age of the gorge was Dr Julius Pohlman. He considered that the gorge of the whirlpool rapids and other portions of the present gorge were of preglacial origin, and so reduced the length of post-glacial time to 3500 years. Since that time numerous estimates of the age of the gorge have been made, the results often varying widely, owing to different interpretations given to the narrow portions of the gorge. It is perfectly evident that, if Niagara was deprived of seven eighths of its water supply, for the period of time during which the gorge of the whirlpool rapids was excavated a very slow rate of recession must have obtained, and hence the age of the gorge is greatly increased. Upham, who does not believe in the withdrawal of the waters, makes the age of the gorge between 5000 and 10,000 years. Spencer and Taylor are ardent advocates of the reduction of the volume of water during a prolonged period, when the supply from the upper Great lakes was cut off.

The former makes the age of the gorge in round numbers 32,000 years, the latter places it tentatively at 50,000 years, though recognizing the uncertainty of many of the elements which enter into his calculations. Prof. G. F. Wright has recently applied a most ingenious method to the solution of this question, and one which seems to eliminate the doubtful factors.[1] This method is based on the measured rate of enlargement of the oldest part of the gorge by atmospheric action. The present width of the river at the mouth of the gorge is 770 feet, and Prof. Wright thinks that it was probably not less at the time when the formation of the gorge began. Assuming that the bank at that time was vertical, he finds that since then the stratum of Lockport limestone at the top has retreated 388 feet. Careful measurements show that the total amount of work accomplished here by the atmosphere since the beginning of gorge formation, was the removal from the side of the gorge of a mass of rock constituting in section an inverted triangle 340 feet high and with a base of 388 feet. This would be similar to a mass with a rectangular section of the same hight but with a base 194 feet wide. The rate of waste of the banks was measured by Prof. Wright as accurately as possible and found to be over one fourth of an inch a year, or a total amount of 610 cubic yards of rock from one mile of the gorge wall. From this he finds that 10,000 years is the maximum amount of time required for the entire change which has occurred in the bank since it was left exposed by the recession of the cataract.

The most recent and most detailed estimates of the age of the gorge have been made by Prof. C. H. Hitchcock.[2] He assumes that the present rate of recession is four feet annually, and finds accordingly that the last formed section of the gorge, from the present falls to the point where it suddenly contracts above the railroad bridges, was formed during 2962 years, which closely agrees with Pohlman's estimate. Thus the beginning of the great cataract at the northern end of the upper great gorge "dates back to 1062 B.C., 300 years before the time of Romulus, or to the reign of King David at Jerusalem." Prof. Hitchcock believes that the gorge of the whirlpool rapids was formed while Niagara drained only the diminished Lake Erie, and he allows a period of 7800 years for the accomplishment of this task. For the erosion of the remaining portion of the Niagara gorge Prof. Hitchcock allows 8156 years. Thus the total length of time required to carve out the Niagara gorge is considered by Hitchcock to be 18,918 years.

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[1] Pop. sci. monthly. 1899. 55:145-55.

[2] Am. antiq. Jan. 1901.

The reader should here be reminded that all such estimates are little more than personal opinions, and that they necessarily vary according to the individual predilections as to greater or less power of erosion possessed by the cataract under the given circumstances. The leading questions concerning the extent of the preglacial erosion in this region, and the changes in volume of water during the lifetime of the Niagara, which are of such vital importance in the solution of this problem, are by no means satisfactorily answered. Nor can we assume that we are familiar with all the factors which enter into the equation. There may be still undiscovered causes which may have operated to lengthen or shorten the lifetime of this great river, just as there may be, and probably are, factors which make any estimates of the future history of the river and cataract little more than a mere speculation. We may perhaps say that our present knowledge leads us to believe that the age of the cataract is probably not less than 10,000 nor more than 50,000 years.

Chapter 3

STRATIGRAPHY OF THE NIAGARA REGION

The stratigraphy of the Niagara region, or the succession of fossiliferous beds, their origin, characteristics and fossil contents, has since the time of Hall's investigations barely received cursory attention from American geologists, whose interest has chiefly centered in the problem of the physical development of the gorge and cataract. A careful examination of the strata of this region and of their fossils reveals problems as interesting and profound as those furnished by the gorge and cataract, and many of them are of far more fundamental and far-reaching significance. Profoundly interesting and instructive as is the " Story of Niagara " and of the physical development of the present surface features, it becomes insignificant when placed by the side of that great history of the rise, development and decline of vast mlutitudes of organic beings which inhabited the ancient seas of this region and whose former existence is scarcely dreamt of by the average visitor to the falls. These ancient hosts left their remains embedded in the rocks of this region; and from the record thus preserved the careful student is able to read at least in outline the successive events in the great drama which was enacted here, in an antiquity so remote that it baffles the imagination which would grasp it. But he who would decipher these records must bear in mind the maxim of La Rochefoucauld: "*Pour bien savoir une chose, il faut en savoir les détails.*" A knowledge of details is necessary to an understanding of the stratigraphic and paleontologic history of this region, and there is no better way of obtaining this knowledge than by a close study of the various sections which expose the strata here described.

The strata of the Niagara region belong to the Siluric series of deposits, which accumulated during the Siluric era of the earth's history.[1] Rocks of Devonic age occupy the southern portion of the district, resting on and concealing the Siluric strata which dip beneath them. (*See* fig. 1, p. 19) As has already been noted, all

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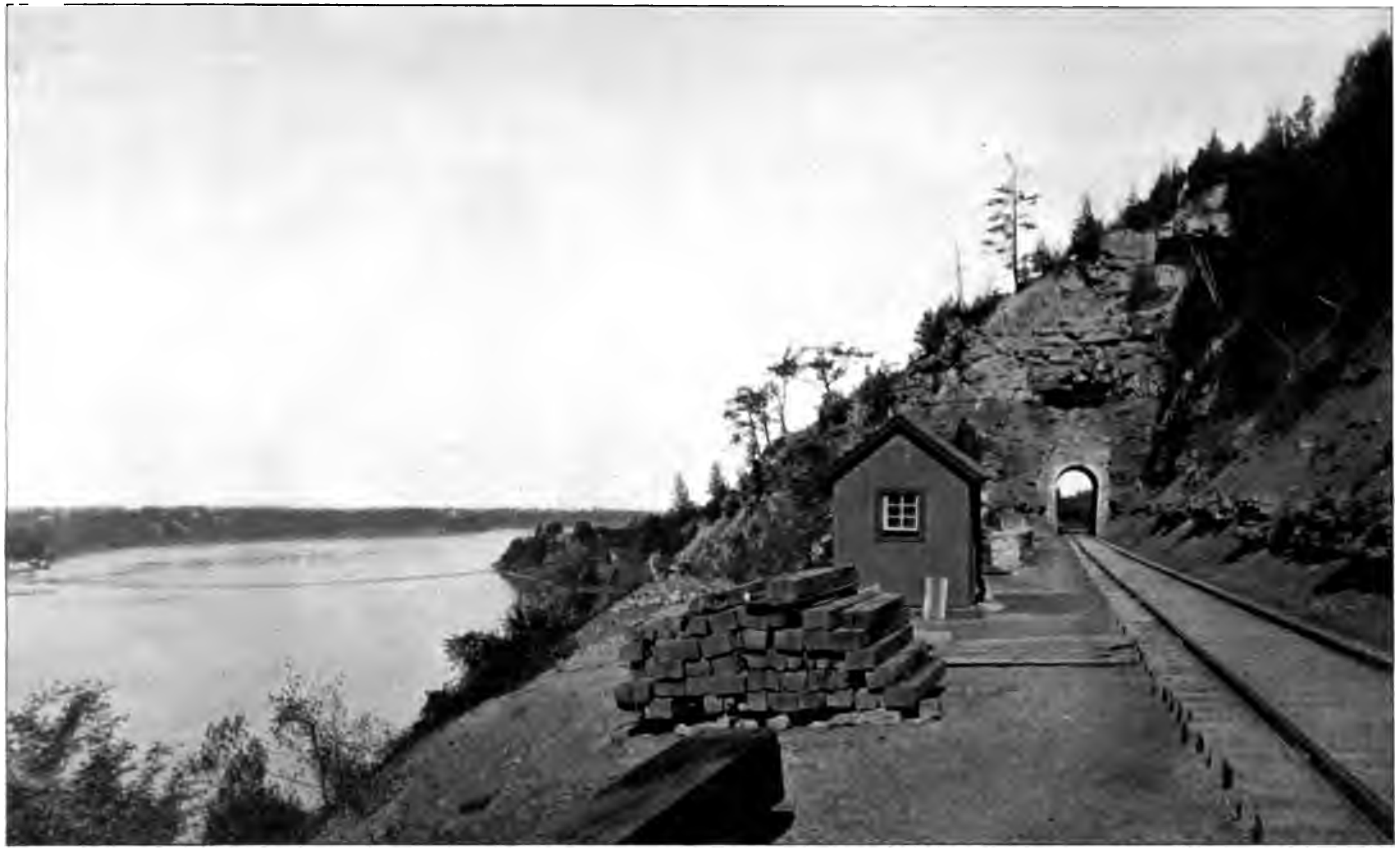
[1] *See* table in chapter 2.



Tunnel through Medina sandstone; N. Y. Central railroad cut, looking north. First shanty and remains of first Lewiston suspension bridge are shown.

the rocks of this region have a gentle southward dip, which permits the lower members to appear progressively as we proceed northward over the surface of the old erosion plane. We may now proceed to describe the various members of this series in ascending order.

Oswego sandstone

This, the lowest member of the Siluric, is not exposed in the Niagara region, as its point of outcrop is now covered by the waters of Lake Ontario. (*See* sections 1 and 2, fig. 7) From borings, however, we know its character and thickness, which in this region is 75 feet.

Medina sandstones and shales

Only the upper portion of this formation is exposed in the Niagara district, where the total thickness is more than 1200 feet.

Red Medina shales. The upper beds of this division are the lowest exposed beds in this region. They are bright red sandy shales, generally of a very uniform character, though occasionally a bed which might almost be called a sandstone occurs. Wherever this rock is exposed to the atmosphere, it rapidly breaks down into small angular fragments, which quickly form a debris slope or talus at the foot of every cliff. In the faces of the older cliffs this rock is so friable, that it can readily be removed by the hand, the fragments themselves being easily crushed between the fingers. In the course of time these fragments disintegrate into a fine reddish clay soil, which when wet has a rather tenacious character.

As the lower part of the Niagara river from Lewiston to Lake Ontario is wholly excavated in this rock, it may be seen wherever the banks are kept fresh by the river, or where small lateral streams enter the Niagara. Where erosion is not active, the shale bank is soon reduced to a slope of red clayey soil, which generally becomes covered with vegetation.

A good place for the study of this shale is on the New York side of the Lewiston suspension bridge, where a fresh cut reveals about 50 feet of the rock. The bridge is 65 feet above the river, and the total thickness of red shale above the water at this point is therefore 115 feet. The shale here as elsewhere will be found to be seamed by whitish or greenish bands, both parallel with and at right angles to the stratification plane. In the latter case they are seen to lie on both sides of a joint fissure, which indicates that the discoloration of the rock, often extending to an inch on either side of the joint, is due to percolating air and water, the latter probably carrying organic acids in solution. The horizontal bands, often several inches in thickness, are probably similarly discolored portions along lines of greater permeability.

No fossils have been found in these shales.

Gray quartzose sandstone. The red shales terminate abruptly and are succeeded by a stratum of gray quartzose sandstone, which is very resistant, and wherever exposed, produces a prominent shelf. This rock varies somewhat in different portions of its exposure, but it averages perhaps 25 feet in thickness. This bed is exposed along the gorge from its mouth to the whirlpool, where it forms a ledge at the water's edge, beyond which it passes below the water level. It is well shown at Niagara glen, where a spring of cool water issues from beneath it, near the water's edge. In the bank on the opposite side, where a fine section of the rocks of the gorge is shown, this quartzose bed is seen in its full thickness, lying between the red shale below and the shales and sandstones above. The red shale at the water's edge has crumbled away, leaving the quartzose bed projecting from the wall in some cases to a considerable extent.

The quartzose sandstone usually forms beds of considerable thickness in this region, though near the top of the stratum a number of thin beds generally occur. The best exposure for the examination of this rock is in the quarries opened up in the terrace on which the Lewiston tower of the suspension bridge stands. In these quarries the sandstone slabs often show smooth surfaces, which generally bear markings similar to those formed by waves on a surface of fine sand. These wave marks are found in most of the sandstones of the Medina group, but they are nowhere in this region so well developed as in the upper thin bedded layers of the quartzose sandstone. No fossils have as yet been found in the gray sandstone on the Niagara river, though farther east a similar quartzose rock shows shells of the Medina Lingula on the surfaces of the layers, which also show wave marks.

cceeding beds of the Medina as well as the Clinton, Roches-
Lockport beds, are best exposed along the railroad cut of
iston branch of the New York Central and Hudson River
. This cut is reached from the Lewiston end through a
nnel cut in the Medina sandstone (plate 12). As the beds
hward, and the roadbed rises in the same direction, we pass
across all the formations from the lowest to the highest
•

shales and sandstones. The contact between the quartzose
ne and the overlying Medina shales is not generally well ex-
xcept in one place. This is in Evan's gully, the first of the
cavations in the roadbed, made by the streams of water
n the spring time cascade from the banks. The quartzose
ne forms the bed of the gully below the bridge on which the
crosses it, and it also forms the capping rock over which the
cascades to a lower level.

e lowest beds of this division of the Medina are gray shales,
in thickness and readily splitting into thin layers and gen-
mooth to the touch, indicating the absence of sand. There
ever beds of a more sandy character, even to fair sandstones,
lded with the shales, and this is particularly the case near the
of this shale mass. These sandstone beds are similar in
r to the quartzose sandstone below the shales, but they occur
layers, separated by shaly masses. These same beds are ex-
n the cutting which leads to the tunnel on the north, where
e shown near the base of the section. They vary in thick-
to 8 inches, and in some cases contain a few fossils, notably
lls of Lingula cuneata (fig. 81). The shales below
dstone layers are mostly below the level of the roadbed, the
t thickness exposed above that, being about 6 feet.

upper 13 or 14 feet of this shaly series are well shown in the
north of the tunnel, where they may be seen above the sand-
just alluded to. These rocks present in places an almost per-
lar wall, where the overlying sandstones have not been re-
while from the rapid weathering of the shale, the capping
enerally projects beyond the face of the shale cliff. The un-

dermining of the upper layers thus results in their ultimate breaking down from non-support, and the resulting fall of rocks may be of a dangerous character. Care is therefore necessary in the examination of these sections, and the warnings of the section guards should always be heeded. These men patrol the tracks continually from early morning till after the last train has passed at night. This is necessary, as the fall of rocks is continuous, and often of such amount as to obstruct traffic for some time. Any one who will watch these cliffs for a time from one of the projecting points where a comprehensive view may be obtained, and note the almost incessant fall of rock particles, will receive an impressive object lesson in the processes by which cliff retreat is effected.

In many cases the shale banks are covered with a coating of red mud carried by rains from the red soil above them. This creates the impression that the color of these lower shales is red like that of the shales higher up in the series, and only after breaking off fresh particles can the true color be seen.

2 These gray shales are succeeded by sandstones and sandy shales, some of the former massive, quartzose and in beds 6 or 7 inches in thickness, separated by shaly layers. The sandstone is gray and often porous, as if it had undergone some internal solution, which suggests that fossils may have been present which were dissolved by percolating waters. Fragments of fossils are occasionally found, but mostly in an unidentifiable condition. Many of the thinner and more clayey beds have raised markings on their under side, which may be indicative of the former presence of seaweeds in the muddy beds of this period. Small black phosphatic pebbles, often very smooth, are not uncommon in some of the layers, and larger masses of black, apparently carbonaceous shale are occasionally found mixed with the sand. In the gray shaly sandstone beds the Medina gastropods and bivalves (pelecypods) occur sparingly, and usually in a poor state of preservation. Some of the thin layers are calcareous, though still containing a large proportion of argillaceous matter. These are generally fossiliferous, the most common organism being a small cylindric bryozoan.[1] Fragments of these

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[1] Identified provisionally as Helopora fragilis (fig. 74).

beds with the bryozoan weathered out in relief on their surfaces, may be found at the base of the cliff in the cut north of the tunnel.

3 In the northern end of the section the sandstones and sandy shales have a thickness of about 5 feet, and are in turn succeeded by 6 feet of shale, weathering readily into a clayey earth, which accumulates, as a talus on the underlying sandstone ledges. As in the other shale cliffs, so here weathering causes a more rapid retreat of the shale than of the overlying sandstone, which therefore projects beyond the shale cliff till it breaks down.

These shales are mostly gray, sometimes greenish gray, with occasional sandstone bands. Toward the top they become intercalated with reddish bands, and finally the prevailing color of the shale becomes red.

4 Following these shales is a mass of sandstone from 35 to 40 feet thick and consisting mostly of beds which vary from 4 to 6 inches in thickness. The sandstone is compact and solid, reddish in color or gray mottled with red. The beds are separated by red shaly partings, with occasional beds of red shale 2 to 4 feet thick. About 20 feet above the base of this sandstone mass is a concretionary layer from 1 to 2 feet thick, which appears not unlike a bed of large rounded boulders. These concretions vary in size up to 3 or 4 feet in greatest diameter, and they lie in close juxtaposition, not infrequently piled on each other, thus still more simulating the blocks of a boulder bed.

This sandstone cliff is in general quite perpendicular, and the thin and comparatively uniform layers, which are regularly divided by vertical joint fissures, produce the appearance of a vertical wall of masonry, for which many people, seeing it only from the rapidly moving train, have no doubt mistaken it. The regularity of these successive beds is at times interrupted by a heavier layer, either red or gray and mottled, which may be traced for some distance, after which it thins out and disappears. This thinning out of the layers in one or another direction is a common and characteristic feature of these sandstones, and is a direct result of the irregularities of current action during the deposition of the sands. We may trace a sandstone mass for some distance, and then find that it disappears by thinning, either bringing the layers above and below it in contact or giving way to a bed of shale.

A careful examination of these individual beds will show the presence of ripple marks in many of them. This indicates moderately shallow water during the accumulation of these sands; for ripple marks are found only down to the depth to which wave action penetrates. These ripples vary greatly in size, a bed about 10 feet above the concretionary layer showing examples in which the crests are from one to one and a half or more feet apart.

The fossils found in these sandstones are the characteristic Medina pelecypods, and the common Medina Lingula cuneata.

5 The thin bedded sandstone layers are followed by 12 or 15 feet of massive sandstones in beds from one to several feet in thickness, and varying in color from reddish to grayish. This rock generally shows strongly marked cross-bedding structure on those faces

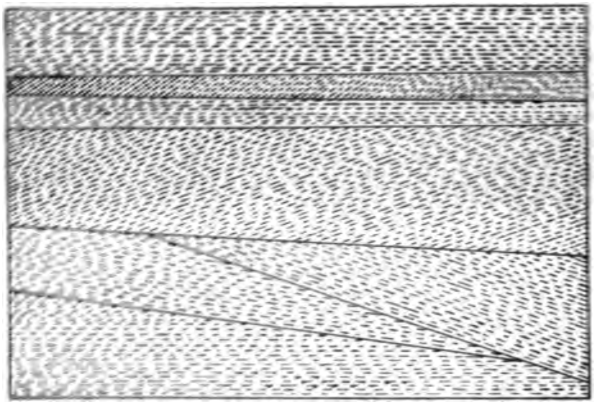
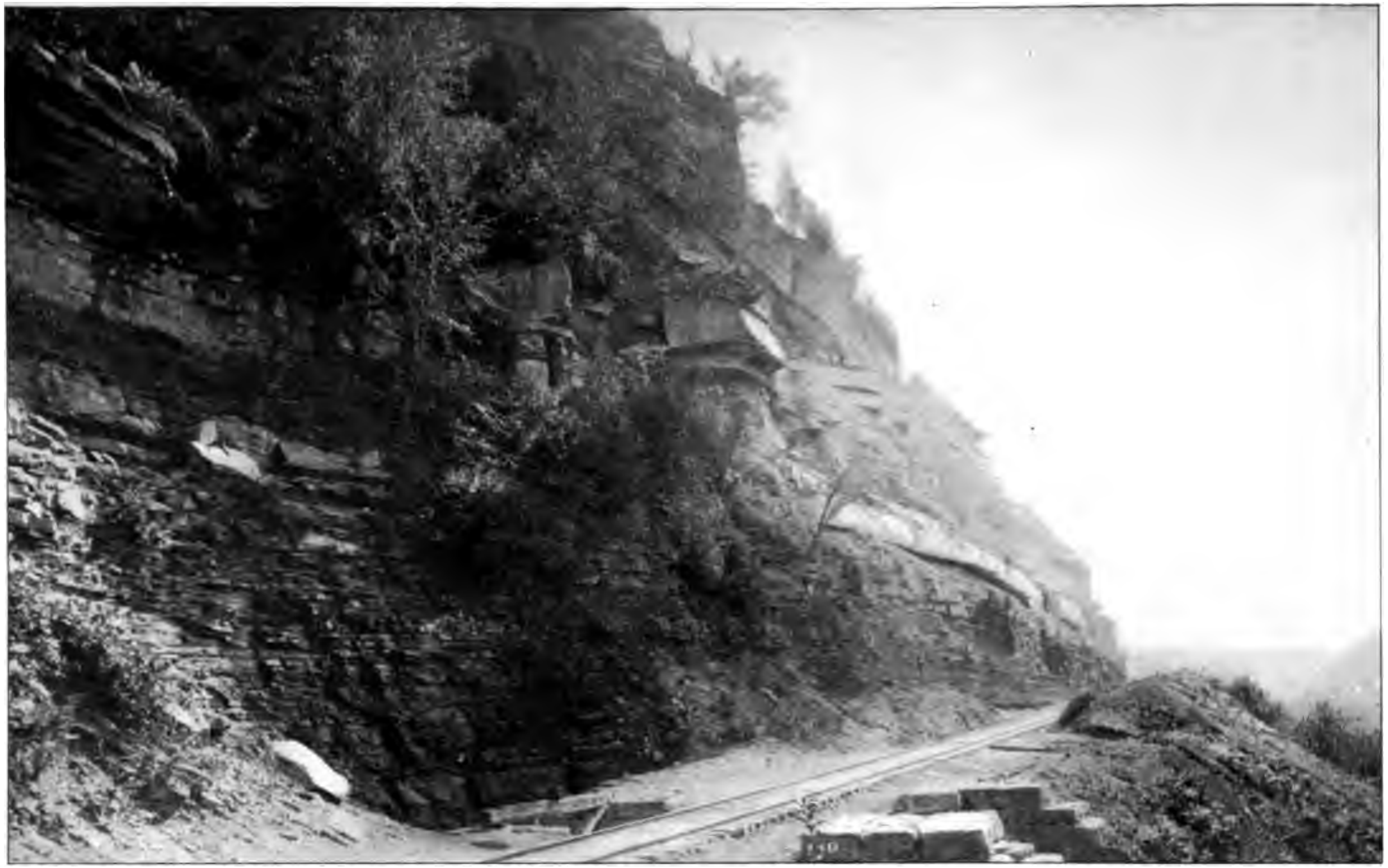


Fig. 20a Cross-bedding in Medina sandstone, Niagara gorge.

which have been exposed for some time. This structure illustrated in figure 20a, copied from a ledge of this rock, indicates diverse current and wave action in the shallow water in which this rock was forming. While the deposition of the strata was essentially horizontal, the minute layers made up of the sand grains were for a
osited at a high angle, much after the manner of deposition
t layers in a delta. After a while the activity of the current
to another direction, and the layers already deposited were
eroded, or beveled across the top, and new layers, inhar-

Plate 13



Section on N. Y. Central railroad cut south of first shanty, looking south. Medina sandstone at base; gray band of upper Medina; Clinton shales and Clinton limestones are shown.

monious with the preceding ones, were laid down on the eroded surface. This was repeated a number of times, as is shown by the succession of changes in the sandstone layers.[1] This structure is sometimes shown on a large scale, as in the case of a bed shown about 200 feet north of " Milk cave ravine ", the second of the small ravines met with in coming from the north. Here some of the layers are very gently inclined, and may be traced for some distance. They are obliquely truncated, other horizontal beds resting on the truncated edges (fig. 20b). (*See also* plate 14)

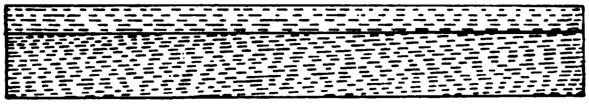


Fig. 20b Contemporaneous erosion and deposition in Medina sandstone, Niagara gorge.

The Medina Lingula (L. cuneata) is found in these sandstones as in the lower ones, but other fossils are rare. Occasionally on the sections the hollows left by the removal of the shells may be seen, while similar cavities, caused by the removal of small black pebbles like those found in the lower layers, also occur. In the upper portions of this mass,on the under side of some thin sandstone lenses resting on and separated by shaly partings, occurs the so-called "jointed seaweed" of the Medina formation, known as Arthrophycus harlani, and illustrated on plate 16. This is a characteristic Medina sandstone fossil, but in this region it has not been found in any of the other sandstone strata. Specimens of this fossil were obtained in digging the great power tunnel at Niagara, but only from the sandstone layers near the bottom of the tunnel, which is about the horizon in which they are found in the gorge section.[2]

6 The highest member of the Medina in this region is a hard, massive bedded and compact quartzose sandstone similar to the

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[1] Compare with this the cross-bedding structure shown in the unconsolidated sands and gravels in the Goat island gravel pit, and in the section of the old Iroquois beach at Lewiston.

[2] The restriction of this characteristic Medina fossil to these upper layers of sandstone at Niagara was pointed out to me by John MacCormick, the watchman of this part of the road, who collects these specimens and keeps them for sale. As he is continually handling these rocks and has handled them for years, he has become familiar with their characters, and is therefore in a position to obtain knowledge of such facts.

quartzose bed terminating the lower shales. While nearly white when fresh, this rock generally weathers to a grayish yellow color and often exhibits yellow iron stains. On the weathered edges cross-bedding structure is well brought out. When separated from the rocks below by a shaly bed, this rock generally projects from the bank for a sufficient distance to form a shelter for the watchman in case of a sudden shower. Where this sandstone comes down to the level of the roadbed, at a projecting cusp of the cliff, it has been cut through and a portion of it left between the track and the gorge. In the shadow of this rock mass stands the second of the watchmen's shanties which we meet with in approaching from the mouth of the gorge.[1] The upper quartzose bed has here a thickness of 7½ feet. Several hundred feet south of this point, where the top of this sandstone is level with the roadbed, a huge ripple, 15 feet from crest to crest, and nearly 2 feet deep, is shown on the river side of the track. This "giant ripple" was described and illustrated by Gilbert,[2] who found other ripples of similar size in the Medina sandstone at Lockport, as well as in the quartzose sandstone near Lewiston.

On the surfaces of the flagging stones which are derived from the Medina sandstones, ripple marks of small size are not uncommon, and the sidewalks of Buffalo and other cities where this rock is utilized, often exhibit fine examples of such rippled rock surfaces.

In the cliff of Milk cave falls (or St Patrick's falls), which is the second lateral fall below the mouth of the gorge, the upper beds of the Medina formation are well shown. The concretionary layer is near the level of the roadbed, and has a thickness of 3 feet. 29 feet above it is the base of the upper gray quartzose sandstone, before reaching which we find that the red sandstone gradually loses its bright color, at first being mottled, and then at times losing its red color altogether, though the thin partings of shale still retain it. The quartzose capping rock consists at the base of a white bed, from 1½ to 2 feet thick and showing cross-bedding structure, followed by shale 1 to 1½ feet thick and of a reddish color in places, and finally by a solid bed of white quartzose sandstone 5 feet in thickness, and like the lower bed, showing cross-bedding structure on the weathered sections. A few thin layers of sandstone overlie this bed, having a total thickness of less than half a foot. On these follow the shales of the Clinton formation.

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[1] This is occupied by John Garlow, on whose beat most of the "Niagara crinoids" (Caryocrinus ornatus) are to be found. Specimens may generally be obtained from him at a small price.

[2] Bul. geol. soc. Am. 10:135-40, pl. 13, fig. 2.

The upper Medina sandstones and shales may be traced in both walls of the gorge nearly to the falls. From the southward dip, the beds progressively pass below the water level, till near the falls only a small portion of the upper beds remains. These may be seen at the river margin in the bottom of the gorge, between the *Maid of the Mist* landing and the carriage bridge on both sides of the river. On the New York side only a few feet of the red sandstones are exposed, the remainder being covered by talus. During high stages of the river these exposed beds are covered by the water. On the Canadian side an extensive ledge of the red Medina sandstone is exposed opposite the inclined railway on the New York side. In the banks behind this ledge the white quartzose sandstone which forms the top of the Medina occurs, its top being at least 25 feet above the water level. It here forms a projecting shelf on which rest huge blocks of limestone broken from the cliff above. From this we may judge that at the foot of the Horseshoe falls the upper layers of the Medina may still be above the water level.

Clinton beds

The Clinton beds at Niagara aggregate about 32 feet in thickness and consist of a stratum of shale at the base and two distinct strata of limestone above this. (*See* Plate 14)

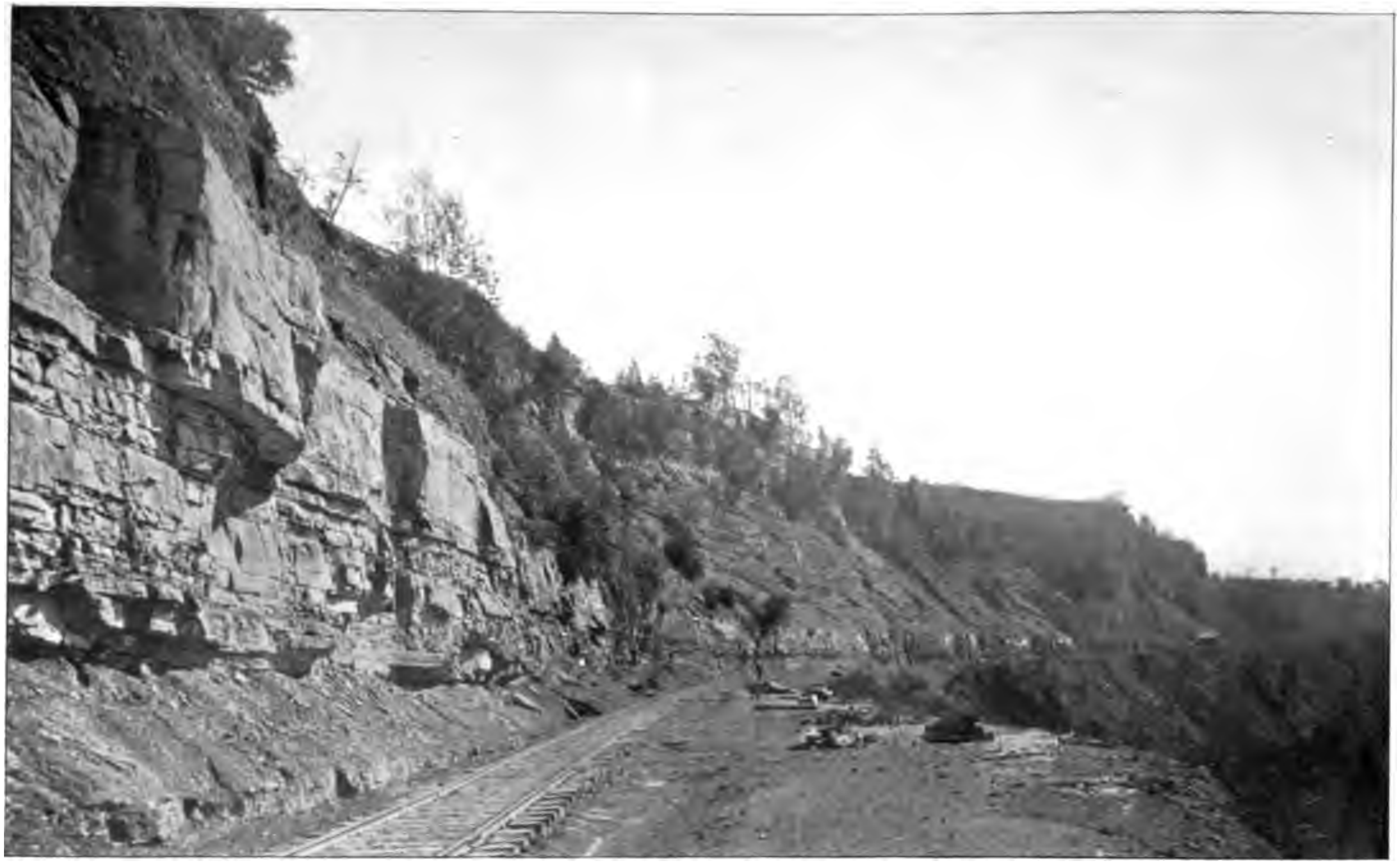
Clinton shale. Resting immediately on the quartzose layers which terminate the Medina formation, is a bed of olive green to grayish or sometimes purplish gray shale, which readily splits into very thin layers with smooth surfaces, and is quite soft enough to be easily crumbled between the fingers. Fossils are rare in it, but occasionally layers are found which have their surfaces covered with crushed valves of small plicated brachiopods, among which Anoplotheca hemispherica and A. plicatula may be mentioned. Other fossils are rarely found except reed-like impressions which are not uncommon. Some impressions have been found which probably belong to Pterinaea emacerata, a pelecypod occurring higher in the Clinton and also in the Rochester shales. The total thickness of these shales is 6 feet.

Clinton lower limestone. On the shale rests a stratum of limestone 14½ or 15 feet in thickness. The lower three or four feet of this rock are compact to granular or finely crystalline, having a sugary texture. Small masses of iron pyrites are not uncommon in this rock, this being the only representative of the ferruginous matter so characteristic of this part of the Clinton beds on the Genesee river and eastward, where a well marked bed of iron ore succeeds the shale. Hall[1] states that "the lower part of the limestone, as it appears on the Niagara river, is highly magnesian, and from the presence of iron pyrites rapidly decomposes, giving rise to the production of sulfate of magnesia, which at favorable points along the overhanging mass upon the river bank, may be collected in quantities of several pounds."

Fossils are not uncommon in this division of the Clinton limestone [illegible]

[illegible]

Plate 14



View on the N. Y. Central railroad cut, looking south, just south of the second shanty; the third is shown in the distance. The formations shown are, from below upwards: the top of the upper gray band of the Medina; the Clinton shale; Clinton lower and upper limestone; Rochester shale, and, in the distant cliff, the Lockport limestone

branching seaweed, Bythotrephis gracilis, may be found. This occurs also on some of the shaly partings of the limestones. The impressions vary from the slender variety of great delicacy to a coarse one in which the frond consists of broad irregular lobes.

This stratum generally forms a vertical wall with the next overlying stratum projecting beyond it.

Clinton upper limestone. In the region of the Genesee river the lower limestone is succeeded by a mass of shale which is generally fossiliferous, and on which lies the upper limestone. In the Niagara region this shale is wholly wanting, the upper limestone resting directly on the lower. The line of separation is however well marked, both by the diverse characters of the two rocks and by the different way in which each resists destruction by atmospheric agencies. The upper stratum is a crystalline and highly fossiliferous limestone, often pinkish in color, though chiefly light gray with yellowish or brownish particles where oxidation has occurred. Portions of the beds consist almost wholly of crinoid stems or joints, which give the rock a coarsely crystalline and sometimes porous aspect. Fossils are abundant in this rock, though the variety is generally not large. The most common species is a rotund variety of the brachiopod, Atrypa reticularis (fig. 112), which is generally very robust and sometimes almost globular in form. Of the other fossils in this rock several Stropheodontas may be mentioned, among them Stropheodonta profunda. A number of rhynchonelloid shells occur, readily recognized by their pointed beaks and strong plications. Among these are some small specimens of Camarotoechia acinus, a species characteristic of the Niagara beds of the west. It is readily recognized by its smooth umbonal area, and its single plication in the mesial depression or sinus, corresponding to which, on the opposite valve occur two plications. Among the more abundant fossils of this rock are smooth elongate and rather strongly biconvex brachiopods of the genus Whitfieldella. The most common is W. intermedia, but other species occur as well. The thickness of this stratum is 11 feet. The upper beds of this series contain species which on the whole are of a strongly marked Niagaran type, such as Spirifer niagarensis and others. A common brachiopod is Strophonella patenta, a flat, thin, subsemicircular shell with a straight hinge line and fine surface striations.

A characteristic feature of this upper limestone stratum is the strong development of stylolite structures. These stylolites are vertically striated columns, from a fragment of an inch to several inches in length, and ranged on either side of a horizontal suture or fissure plane in the limestone bed. Projecting from both upper and lower beds, they interlock with each other and so produce a strongly marked irregular suture. This structure is characteristic of limestone beds of this type, but its origin is still obscure. Pressure of superincumbent layers of rock seems to have been the chief cause of their production, this pressure acting unequally on the rock mass, from the presence of fossils or from other causes. A characteristic feature is the open suture at the ends of the columns, which gives the layers the aspect of having separated by shrinkage along an irregular plane. The vertical striations indicate motion either upward or downward.

The Clinton limestones may be seen in both banks of the river where not covered by vegetation, from the mouth of the gorge to within a short distance of the falls, near which they are covered by talus. They always form a cliff in the profile of the gorge, the 6 feet of shale below them forming a sloping talus-covered bank, below which there is another cliff formed by the hard upper Medina sandstone, the lower members forming one or more talus-covered slopes down to the quartzose bed of the Medina. This latter is again a cliff-maker, and generally projects from the bank, while the soft red shale below invariably produces a sloping talus-covered bank. Above the Clinton limestones is another slope and talus formed by the soft Rochester shale, above which a precipitous cliff is formed by the Lockport limestone.

At the base of the cliffs, fallen rocks of the Clinton limestones are mingled with those from the overlying Lockport limestones, and care must be exercised in discriminating between these when collecting fossils. Halfway between the third and fourth watchman's shanties on the railroad, where the top of the Clinton limestone is on a level with the roadbed, this rock was formerly quarried on the river side, and here a good opportunity is afforded to collect fossils from the limestone fragments. Blocks of the various limestones are also seen by the side of the track between the second and third shanties.

At the whirlpool on the Canadian side the Clinton limestones are seen in both banks of the old St Davids gorge, the section on the west showing glacial striae. Near the foot of the eastern wall of this old gorge and on the talus heaps which flank it, are large masses of calcareous tufa often inclosing leaves, moss or other vegetable structures. These masses appear to come from the horizon of the Clinton limestone, though they have not been seen in place, and it is not improbable that a "petrifying spring" carrying a strong solution of carbonate of lime issues from this rock. Springs issue abundantly from between the two members of the Clinton limestone, and they carry lime in solution, as is indicated by the deposit of soft calcareous ooze on the rocks and other substances over which this water flows. On exposure to the atmosphere this ooze will dry and harden. The joint faces of the Clinton limestone are everywhere veneered over with a thin deposit of calcium carbonate.

Limestone lenses of the Clinton. At intervals in the upper Clinton limestone may be seen large lenticular masses of a compact, hard and apparently structureless limestone, often concretionary and not infrequently showing numerous smooth and striated surfaces of the type known as "slickensides" and which are indicative of shearing movements. One of these masses is visible in the bank opposite the third watchman's hut. Its greatest thickness is about 8 feet, and it lies between the upper limestone and the overlying shale, being partly embedded in both. The rock is often cavernous or geodiferous, the cavities when freshly broken being filled by snowy gypsum or grayish anhydrite. Fossils are abundant in this rock.

Several other lenses of this type are visible in the upper Clinton limestone where it is crossed by the Rome, Watertown and Ogdensburg railroad below Lewiston hights. These masses are however entirely inclosed by the limestone, from which they are differentiated by their structureless character. The lenses exposed on the Rome, Watertown and Ogdensburg road are rich in shells of orthoceratites and shields of trilobites (Illaenus ioxus), while the lens in the gorge yields chiefly brachiopods, the most abundant of which are the smooth Whitfieldellas, the small W. nitida and the larger W. oblata being the most common.

The following species have been obtained from the lens in the gorge:

Brachiopoda

1 Whitfieldella nitida abundant
2 W. nitida oblata abundant
3 W. intermedia common
4 Atrypa reticularis; specimens with strong, rounded bifurcating striae, noded at intervals by strong concentric striae, and apparently intermediate between the typical form of the species as it occurs in the Clinton and upper limestone and A. nodostriata, the most abundant form of the Rochester shales.
5 Atrypa nodostriata; rather common, convex and more elongate than in the shale above, with the plications generally sharper and bifurcating near the front. The pedicle valve has a distinct sinus bordered by strong plications, the corresponding fold being marked merely by strong plications. Anterior margin distinctly sinuate. The nodulations are not well preserved except in specimens from the shaly portions.
6 Atrypa rugosa; several small specimens, both valves very convex, with strongly defined sinus in pedicle valve, in the center of which is a small plication. Plications bifurcate and also increase by intercalation; crossed by strong rugose lines.
7 Rhynchotreta cuneata americana rare
8 Camarotoechia neglecta rare
9 Anastrophia interplicata rare
10 Spirifer niagarensis; common, large and robust, with long hinge line and moderately high area, and strongly incurved beak. The sinus is flanked by two stronger plications and extends to the beak. The plications are flattened on top.

11 Spirifer radiatus: common but generally crushed: with an extended hinge line and form and proportions similar to the preceding species. The striae are fine and flat on top with very narrow interspaces altogether very similar to those covering the plications of S. niagarensis. A scarcely defined plication appears on each side of the sinus in some specimens, and in these the sinus is rather sharply defined and angular at the bottom. In others the sinus is shallow rounded and not definitely outlined by incipient plications. In the more elongated specimens the cardinal angle is well defined, but in the shorter specimens it is rounded.

12 Spirifer crispus	rare
13 Spirifer sulcatus	rare

14 Dalmanella elegantula: rare and with greater convexity than that of the specimens in the overlying shale.

15 Plectambonites transversalis	rare
16 Leptaena rhomboidalis	rare
17 Stropheodonta corrugata	rare
18 Orthothetes subplanus	rare
19 Strophonella patenta	rare

Gastropoda

20 Platyostoma niagarensis	rare

Trilobites

21 Illaenus ioxus; fragments of caudal and cephalic shields crowded together into masses sometimes of considerable size.

22 Calymene blumenbachi	rare

Bryozoa

23 Lichenalia concentrica; common in very irregular and much distorted masses.

Corals

24 Enterolasma caliculus	common

Crinoids

25 Eucalyptocrinus; fragments of root stem and calyx.

In the lenses below Lewiston hights the same species except nos. 2, 3, 9, 10, 14, 15, 17 to 20 and 25 have been found. Rhynchotreta cuneata americana has more the features of the same species from the western Niagara than those of the Rochester shale species.

Spirifer crispus is commonly deficient in plications approaching in this respect and in the character of the sinus, S. eriensis from the Manlius limestone. Atrypa nodostriata is robust, convex, with coarse rounded plications and rather faint concentric striations, characters intermediate between A. reticularis of the Clinton and A. nodostriata of the Rochester shale. Besides these species and some not yet identified, the following occur.

Cephalopoda

26 Orthoceras annulatum

27 O. medullare (?) rare

28 O. sp.

Pelecypoda

29 Modiolopsis cf. subalatus?

The origin of these lenses is still obscure. Many of the fossils found in them are characteristic of the Niagara group of the west, but are rare or wanting in the Niagaran of New York. This is specially the case with the trilobites (Illaenus ioxus) and the cephalopoda. Dr E. N. S. Ringueberg many years ago studied these limestone masses as exposed at Lockport and other more eastern localities, and he termed them the "Niagara transition group".[1] He found in this rock 32 Niagara species, 11 species common to the Clinton and Niagara, two species found otherwise only in the Clinton, and two species not found outside of this rock. The origin and significance of these unique deposits are being carefully studied by the state paleontologist.

Rochester shale

The Rochester (Niagara) shale has a total thickness of about 68 feet in the gorge of the Niagara. It is here divisible into a lower and an upper half. The lower portion is a highly fossiliferous shale with numerous limestone bands, and terminates in a series of thin calcareous beds with shaly partings in all about 4 feet thick, and extremely rich in bryozoa. The upper 34 feet are quite barren and have few limestone layers.

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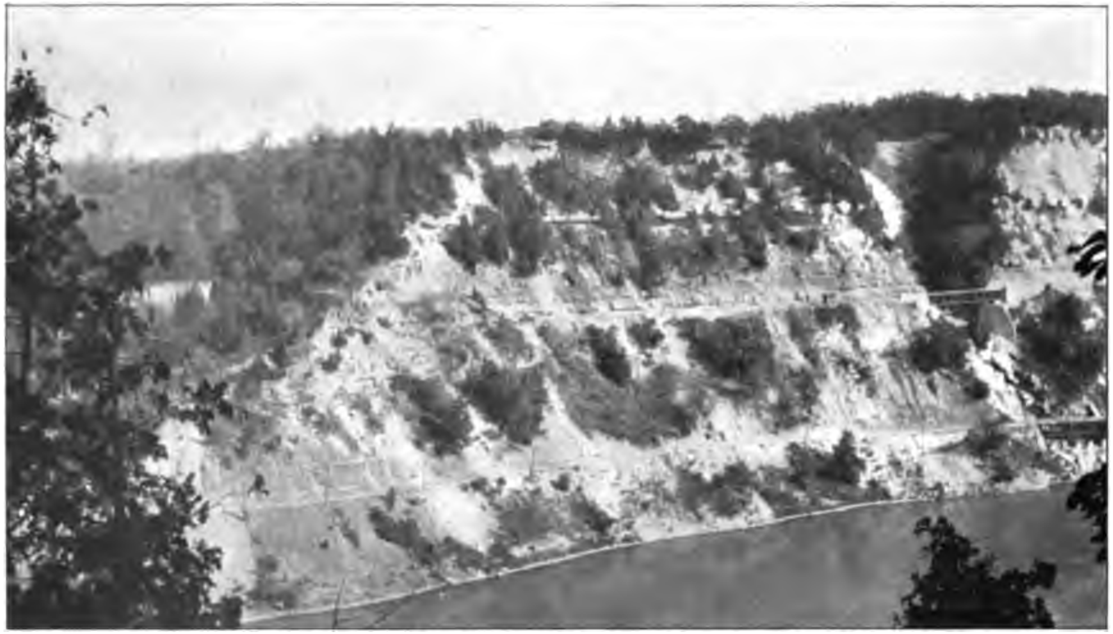
[1] Am. nat. 1882. 6:711-15.

Plate 15



View of the New York bank a short distance north of the Devil's hole. The gorge-road is shown below, and the New York Central railroad cut near the middle. The fourth shanty is shown a short distance to the left (north) of the bridge.

Lower shales. The beds immediately succeeding the Clinton limestone are calcareous shales with frequent thin limestone layers. The latter are the most fossiliferous, being in general entirely made up of organic remains. The calcareous beds of the lower 5 or 10 feet are particularly rich in crinoid remains. Chief among these organisms, on account of its abundance and perfection, is the little triangular Stephanocrinus ornatus, which may be found in most of the calcareous layers. Fragments of Eucalyptocrinus are always common, while the characteristic Niagara cystoid Caryocrinus ornatus is also found, though not so abundantly as in the upper part of the lower division. The most abundant brachiopod of the lower shales is Whitfieldella nitida oblata, similar to the specimens found in the limestone lenses. The little Orthis, Dalmanella elegantula, is also common, ranging throughout the lower division of the shales. Spirifer niagarensis is common above the lowest 3 or 4 feet of the shale. Orthothetes subplanus, a large, subsemicircular and nearly flat brachiopod, is abundant in some of the calcareous layers, which at times seem to be composed of it, so thickly are these shells piled one on the other. Atrypa nodostriata is the commonest representative of the genus, the larger A. reticularis, so abundant in the upper Clinton, being comparatively rare and subordinate in development. In the limestone bands A. nodostriata is usually rotund, but in the shaly beds it is most commonly compressed. Trilobites are comparatively rare in these lower shales, though representatives of all the species found in this region have been obtained from them. Bivalve molluscan shells are also uncommon, but the gastropods, Diaphorostoma niagarense and Platyceras are not infrequent.

Some of the calcareous bands are almost barren of organic remains, but in most cases these beds will be found to constitute the chief repositories of the fossils.

Bryozoa beds. A short distance south of the third watchman's hut, the section comes to an end, being for some distance replaced by a soil-covered and more or less wooded bank. Where the section ends the upper Clinton limestone is only a few feet above the roadbed, and the shale above it is accessible. 29 to 30 feet above the top of the limestone, a group of calcareous beds rich in bryozoa project from the bank, being readily traceable for some distance on account of their compact nature. Their total thickness is about 4 feet, and they consist of numerous thin limestone layers with shale partings of greater or less thickness. On the weathered surfaces of the limestone layers, the bryozoans stand out in relief, and such surfaces will often be found completely covered with these delicate organisms. The cylindric types prevail, but the frondose forms are also common. With them occur brachiopods and other organisms. Slabs of this rock are often found on the talus slopes, and they are among the most attractive objects that meet the collector's eye. The section begins again, after an interruption of perhaps a quarter of a mile, near the old quarry in the Clinton limestone. (Plate 15) Between the river and the railroad are several mounds of shale, which were left in place when the railroad cut was made. These are subject to disintegration, and the fossils in consequence weather out. They may be picked up on these mounds completely weathered out, and often in perfect condition. The best of these mounds is about halfway between the old Clinton limestone quarry and the fourth watchman's hut. Here the top of the mound is on the level of the top of the Bryozoa beds, the whole thickness of which is therefore included in this remaining mass. As these beds are extremely fossiliferous, this mound is a productive hunting ground.[1]

An equally productive locality for weathered-out fossils is the slope of disintegrated shale rising from the Rome, Watertown and Ogdensburg railroad tracks above Lewiston hights. The best hunting ground is in the little gullies made by the rivulets of rain water in the bank. Some glacial till is here mingled with the clay from the decomposed shales, and it requires a little attention to distinguish the two.

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[1] The fossils here obtained are extremely delicate and brittle. They should be placed at once on layers of cotton batting, in a small box and covered with similar material, the box being completely filled. This is the only way in which many of these delicate fossils can be carried away without breaking.

Upper shales. Above the Bryozoan beds the shale is soft, and more evenly and finely laminated, splitting often into thin slabs of moderate size. Hard calcareous beds are generally absent, though occasionally found near the top. The stratification and lamination is much more strongly marked in this than in any other division of this rock. When freshly broken, the shale has a brownish earthy color, which changes to grayish when the rock decomposes to clay. Fossils are rare, those found being seldom well preserved. In most cases the shells are dissolved away, leaving only the impressions of the fossil, which from compression become faint, and are not readily recognized without careful scrutiny. The most common remains found in these rocks are bivalve mollusks (pelecypods) and trilobites. Among the former Pterinaea emacerata is the most abundant, while Dalmanites limulurus is the chief among the trilobites of these beds. Other trilobites also occur in these shales, notably Homalonotus delphinocephalus, as well as a number of brachiopods.

Toward the top fossils become rarer, and finally are wanting altogether. The shale becomes more heavy bedded, and calcareous layers begin to increase. The last 10 feet or more are quite calcareous and compact, and have an irregular fracture. They grade upward into the basal layers of the Lockport (Niagara) limestone.

Lockport (Niagara) limestone

The limestone which succeeds the Rochester or Niagara shales forms the summit rock of the series from the edge of the Niagara escarpment to south of the falls. It consists of a number of distinct strata, of varying characters, most of them very poor in organic remains. The total thickness exposed in the Niagara region is not over 130 feet, but borings show that the thickness of the limestone lying between the Rochester shale and the Salina shales is from 200 to nearly 250 feet. Some of the upper beds of this limestone mass may represent the Guelph dolomite and others may belong to the base of the Salina beds. Nevertheless we may confidently assume that the thickness of the Lockport limestone in this region, is at least 150 feet.

Hydraulic cement beds. 1) The lowest stratum of the series is a hard, compact, bluish gray silicious limestone, weathering whitish on the exposed faces, and breaking into numerous irregular fragments larger near the bottom of the stratum but becoming small, angular and subcubical near the top, where the weathering is similar to that obtaining in the upper parts of the shales. This stratum varies from 7 to 8 feet in thickness being in places divided into two tiers, the upper one, 4 feet thick, appearing as a distinct bed. This weathers to a creamy gray color, and breaks into small angular fragments with no regularity of fracture, and independent of the plane of stratification. On some of the weathered edges of this rock irregular stratification lines are visible, giving the beds the appearance of a fine grained sandstone. Occasionally small geoditic cavities occur lined with dolomite or gypsum. The line of contact between this stratum and the underlying shale is an irregular one, the shale surface having a wavy character.

2) This rock is succeeded by a 4 foot stratum of arenaceous limestone which shows no well marked stratification lines on the weathered surfaces, though in places a distinct cross-bedding structure appears. It peels off in irregular slabs parallel to the cross-section, i. e. at right angles to the stratification plane. Near the top of this stratum are a few thin beds which show the finer stratification structure on the weathered edges, the character of this structure being such as is found in fine grained sandstones.

Both these strata appear to be wholly destitute of fossils. It is not improbable however that the scattered geodes represent the places where corals or crinoids occurred, which have subsequently been altered or dissolved out. Aside from this, there is no evidence that this rock ever was fossiliferous, and it is most probable that it represents the accumulation of fine calcareous mud or sand.

Crinoidal limestone. 3) The compact hydraulic rock is abruptly succeeded by a stratum of highly crystalline limestone, on the weathered surfaces of which joints of crinoid stems and other organisms stand out in relief, particularly in the lower part of the stratum. The rock is entirely composed of fragments of organisms which were ground up and mingled together in great profusion. Oblique bedding lines may be observed occasionally, indicating that the fragments were subject to wave action. The stratum varies in thickness from 5 to 6 feet, and is occasionally divided by horizontal sutures which show a marked stylolitic structure similar to that found in the crystalline upper Clinton limestone. The contact between this and the underlying stratum is wavy. This rock has been quarried at Lockport under the name of Lockport marble.

Geodiferous limestones. The crinoidal limestone is succeeded by strata all of which are more or less geodiferous, though varying considerably in composition and structure.

4) The rock immediately following on the crinoidal bed is a 4 foot stratum of compact, gray fossiliferous limestone, the fossils being of a fragmentary character. Stratification structure is well marked on the weathered surfaces, specially in some of the lower beds of the stratum. Sometimes there is only one thick bed, at others the stratum consists of a number of thin beds with a heavy one near the center. The thin beds show the stratification structure best, having at the same time a strongly granular character. As the fossils are fragmentary, and only accessible on the weathered surfaces, little is known of the organisms that constitute it. Crinoid joints occur, but they are less characteristic of this than of the lower stratum. Geodes however are not uncommon, the cavities being lined with crystals of pearl spar (dolomite) or filled with masses of snowy gypsum.

5) The fifth stratum of limestone in this series is a finely crystalline magnesian rock, like the others destitute of fossils except in so far as these are represented by geodes. The latter are common and filled with alabaster, or sometimes with massive or crystallized anhydrite. The latter is distinguished from the crystallized gypsum or selenite, which it closely resembles, and which occasionally occurs in the same beds, by the cleavage, which is rectangular and nearly equally perfect in three directions in anhydrite, while it is perfect in one direction only in the selenite.

6) A finely crystalline, somewhat concretionary dolomitic limestone, 3 feet thick, next succeeds, the weathered sectional surfaces of which, buff in color, show the fine stratification structure, which

is of the type of the cross-bedding structure in sandstone. Such structure indicates that the bed possessing it was a fine calcareous sand, subject to shifting movements by waves and deposited in moderately shallow water. We need look for organic remains in such a rock with no more assurance of finding them than we bring to the examination of uniform bedded shales. They may be abundant or they may be rare or absent altogether. Thus a limestone need not be necessarily a fossiliferous rock.

Geodes of the usual type are common, the dolomitic lining predominating.

7) On the preceding thin stratum follows a limestone mass of very uniform character, hardly separable into district strata, though consisting of numerous beds.[1] 27 feet of this stratum are shown at the quarry near the northern end of the section, where the upper exposed bed forms the surface rock of the plateau above. The beds are generally of considerable thickness, but the fine stratification structure is not so well marked as in the strata below. The rock may be considered a compact granular dolomite, in which considerable change has taken place since its original deposition. It is of a grayish color but weathers to a lighter tint. Geodes are plentiful, often quite large, and in these, minerals of great beauty are not infrequently found. The most common are the snowy variety of gypsum or alabaster, the darker gray, massive, fine anhydrite and the uniform, fine, dolomite rhombohedra with curved faces, generally of a pinkish tint and familiarly known as pearl spar. Long slender crystals of calcite, generally in the form known as scalenohedra, or dogtooth spar, are not uncommon. These are commonly of a golden color, and large enough to show well their crystal faces. In the new power tunnel which was excavated in the neighborhood of the falls, large masses of transparent gypsum of the selenite variety were found in cavities in this rock. Some of these pieces were 6 inches in length. Masses of limestone lined with pinkish dolomite crystals and occasional large masses of silvery selenite, and set with

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[1] The distinction between stratum and bed is an important one. A stratum is a rock mass having throughout the same lithic character, and may be thick or thin. A bed, on the other hand, is that portion of a stratum limited by horizontal separation planes. *See* Geology and paleontology of Eighteen Mile creek pt 1. Introduction.

amber crystals of calcite, were also found in these cavities, the combination being such as to produce specimens of great beauty. Among the rarer minerals found in this rock is the crystallized and cleavable anhydrite, which like gypsum is a sulfate of calcium, but without the water which is characteristic of that mineral. Anhydrite crystallizes in the orthorhombic system, and its cleavage is in three directions, at right angles to each other (pinacoidal), thus yielding rectangular fragments and enabling one to distinguish it from selenite with little difficulty. It is also a trifle harder than selenite which is easily scratched with the finger nail. This form of anhydrite is rather rare, the principal localities for it being foreign. Masses of considerable size have been found in the limestone of this quarry, and small pieces are not uncommon in the geodes of these strata. Both selenite and the cleavable anhydrite are commonly called "mica" by the uninitiated; that mineral however does not occur at Niagara. Small masses of fibrous gypsum or satin spar have been found, but these are very rare. The satin spar of which the cheap jewelry sold in the curiosity shops is made is not from Niagara.

Among the metallic minerals found in this rock, zinc blende or sphalerite is most common. It is generally of a yellowish or light brownish color and brilliant resinous luster. Large masses however are rare. Galenite or lead sulfid crystals are also occasionally found, but this mineral is comparatively rare. In addition to these, iron pyrite, iron-copper pyrite (chalcopyrite), green copper carbonate (malachite), fluor spar (fluorite), iron carbonate or brown spar (siderite, generally ferruginous dolomite), strontium sulfate (celestite) and native sulfur as well as other minerals are met with.

The total thickness of the limestone exposed in this section is thus somewhat more than 55 feet. At Lewiston hights, on the edge of the escarpment, only about 20 feet are exposed. This includes the two lower strata of hydraulic limestone, the crinoidal limestone and a few feet of the lowest geodiferous beds (stratum 4). Over this lie some two or three feet of glacial till. The distance between the edge of the escarpment and the quarry at the end of the section, is a little over a mile and a half, the increase in thickness of the limestone and the rate of dip (since the surface is about level) is therefore a trifle less than 25 feet in the mile.

The crinoidal limestone is the most prominent stratum on the edge of the escarpment. From its base springs of cold and clear water issue at numerous places along the outcrops, both on the edge of the escarpment and in the gorge. The most prominent of these is at the head of "Milk cave" or St Patrick's falls, and here as almost everywhere at the base of the crinoidal limestone, shallow caverns abound. One of these caverns near the head of the falls, has a depth of 35 or 40 feet and is high enough to permit one to walk upright. No stalactites are found in these caverns, but the walls are much disintegrated and in places covered with a fine residual sand.

In the fields above this cavern are several sink holes of moderate depth, which serve as catchment basins for the waters of the surrounding country, which issue from these caverns during the wet seasons.

The cavern known as the Devil's hole belongs to this category. As in the other caverns, the roof is formed by the crystalline crinoidal limestone (stratum 3), the cavern itself being hollowed out in the hydraulic cement rock. This cavern is deeper than most others, and at the end a spring of deliciously cool water issues from between the two beds, the upper "spring line" of this region. There is no evidence that the cavern extended any deeper than it does at present, nevertheless the spot is worth visiting, as it is the only accessible one of the numerous springs and caverns. The fall of the Bloody run at this place is over a thickness of almost 60 feet of limestone, and the chasm which this stream has worn is interesting both from its historic and scenic points of view.[1]

West of the Niagara river on Queenston hights several quarries have been opened in these limestones, some distance south of the edge of the escarpment. The rock quarried is the crinoidal limestone and overlying beds. The total depth of rock in the quarry is 27 feet, of which the lower 14 or 15 feet are bluish gray and the upper of a lighter gray color. The limestone is here much more uniform, crystalline throughout and more fossiliferous. This may indicate a nearness [illegible] the material for these [illegible] occur in this rock [illegible] gorge. Below the [illegible] which is from [illegible] the limestone quar[illegible]

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[1] See brief mention of Bloody run massacre in Introduction.

Owing to the resistant [illegible] posed in the gorge [illegible] pendicular. Large [illegible] one of the largest of these [illegible] road. This is a block [illegible] fallen from above and [illegible] angle of about [illegible]

The limestones are well exposed [illegible] the railroad bridges, but [illegible] to walk on this [illegible] the shale is here very irregular [illegible] prior to the deposition of the limestone [illegible] also somewhat concretionary [illegible] masses [illegible] the shales. The succession of strata is here as follows

1 Concretionary, irregularly bedded gypsiferous limestone, often earthy and with occasional thin, shaly layers; it splits readily into slabs perpendicular to the stratification. Thickness [illegible] feet.

2 Fine grained limestone with sandy feel, sometimes massive, sometimes in shattered layers with earthy or shaly partings and separated from the underlying rock by an earthy layer. It weathers to an ashy or sometimes an ochery color, and varies somewhat in thickness. The upper layer is however a solid and fine grained limestone. Thickness 4-4.5 feet.

Strata 1 and 2 are the equivalent of the cement beds.

3 Crystalline and crinoidal limestone abruptly succeeding the lower bed. It is massive though somewhat thin bedded and contains geoditic cavities filled with gypsum. This continues uniform for a thickness of about 19 feet.

4 Compact limestone; concretionary with cavities containing gypsum and other minerals, and with sphalerite embedded in the rock,

The bedding and upper contact lines are irregular. Thickness 14-15 feet.

5 Compact, finely crystalline and homogeneous dolomitic rock, showing traces of fossils and slickensides. Beds showing Stromatopora common. In places the rock has a porous appearance and is rich in geoditic cavities, which are lined with dolomite and calcite crystals. Thickness 19 feet.

This stratum forms the lower portion of the cliff at the first cut on the gorge road, and the basal part of the mass left standing on the river side. Heads of Stromatopora may be seen in this rock, some of the geoditic cavities having replaced this fossil. This is about the summit of the beds exposed in the quarry at the end of the railroad section.

6 Earthy, compact dolomite in thin layers, which give the cliff the appearance of a stone wall. Toward the top the rock becomes more compact and heavy bedded, this giving the appearance of an overlying stratum. This rock is full of geodes lined with pearl spar or dolomite, the cavities ranging in size up to that of a fist or larger. The beds are generally less than a foot in thickness, the average being from 3 to 6 inches. Toward the top of the cut, the rock becomes more compact and finely crystalline, but otherwise remains similar. Pearl spar geodes remain common to the top. The thickness of this mass, at the beginning of the gorge road, is about 45 feet.

The total thickness of the limestone exposed on the gorge road is in the neighborhood of 110 feet. This is double the thickness found at the quarry, the distance between the two points in a straight line being about three miles or nearly four following the curvature of the river. The rate of increase in thickness, or the amount of dip of the strata is therefore about 20 feet to the mile.

Almost the only recognizable fossils found in these limestones, excepting the crinoid fragments, are the hydro-coralline Stromatopora (concentrica Hall) and the coral Favosites. Both occur in the middle and upper portions of the exposed mass, and may generally be seen in the weathered upper surfaces of the limestone beds. Thus wherever these beds are exposed on the surface, as at the whirlpool on the Canadian side, at the fall of Muddy brook, and near Clifton, these fossils are generally weathered out in relief. They are however not readily separated from the rock. Many of the geodes still show traces of coral structure, which is sometimes shown in the included gypsum.

The limestone is well exposed in the cliff at Goat island, where it has a total thickness of about 110 feet. The contact between the shale and limestone can be seen near the entrance to the Cave of the Winds, where it is about a foot above the top of the stairs. The roof of the Cave of the Winds is formed by the crystalline crinoidal limestone, the same bed which forms the roofs of all the minor caverns along the gorge. The cement beds, about 10 feet thick, together with the 70 feet of Rochester shale, are removed by the spray to a depth of perhaps 30 or 40 feet, the floor of the cave being probably on the upper Clinton limestone, thus making the hight of the cavern 80 feet. Floored and roofed by resisting beds of crystalline limestone, this great cavern is a fit illustration of selective erosion by falling water on rocks of unequal hardness.

The massive limestone which forms the vertical cliff of Goat island is 68 feet thick, its base being on a level with the foot of the Biddle stairway. The top of this cliff marks approximately the level of the falls on either side of Goat island, which therefore have a total thickness of nearly 80 feet of limestone, of which however the lowest 10 feet yield to erosion as does the underlying shale. We may thus say that at the falls there are 70 feet of resistant limestone on top, and 80 feet of yielding shales and limestones below. As the crest of the falls approximates 160 feet above the river below, at least 10 feet of Clinton limestone are found above the water level.

From the top of the vertical cliff at Goat island a sloping bank exposing thin bedded limestones, overlaid by about 10 feet of shell-bearing gravels, rises to a hight of about 40 feet, while on either side of Goat island these thin bedded limestones form the rapids above the two falls. As the total hight of the rapids is about 50 feet, and, as they are formed along the strike of the beds owing to the right-angled turn in the river at this point, the thickness to be added to the known limestone mass is not over 50 feet, giving a total thickness of 130 feet of limestone exposed within this region.

Guelph dolomite

This rock, named from its occurrence at Guelph (Ont.) about 75 miles northwest of Niagara falls, is, so far as known, absent from the Niagara district. As before noted, it may however be represented in the buried hundred feet of limestone (more or less) which lie above the 130 feet of known rock, as shown by the borings in this region.

Salina beds

The basal beds of the Upper Siluric are the saliferous shales and calcareous beds of the Salina stage, so named from the salt-producing village of Salina in Onondaga county. This is the horizon which furnishes all the salt, as well as the gypsum of New York state and the adjoining territory. In the Niagara region this formation is not well exposed, owing to the soft character of the rock which has permitted deep erosion in preglacial times, and to the extensive drift deposits which cover it. The only known exposures on the Niagara are on Grand island and on the Canadian side of the river opposite North Buffalo. On Grand island the Salina rocks may be seen at Edgewater about 200 yards below the boat landing. Here the following section is exposed.[1]

3 Light colored, soft, friable gypseous shales, 5 feet
2 Greenish shales containing nodules of gypsum, 1½ feet
1 Black shale in the river bed

The exposure extends 300 yards down the river bank.

At the extreme northern end of the island, where it divides the river, an impure, thin bedded limestone of this series is exposed. The exposures on the Canadian bank begin a short distance south of this, and extend to the International bridge, the rock here being a more or less gypsiferous shale.

From the numerous borings in this region we have however gained a fair knowledge of the character and thickness of this rock, the latter averaging, according to Bishop, 386 feet. The best available record of the rocks lying between the Waterlime and the Niagara series of limestones is the core of a well drilled on the land of the Buffalo cement co. in North Buffalo. This core, which has a is now preserved in the museum of the Buffalo sciences, and from it the following succession of nstrated.[1]

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[1] Bishop. 15th an. rep't N. Y. state geologist. 1895. p. 311.

	Feet
erlime above the mouth of the well, about	7
le and cement rock in thin streaks	25
rably pure cement rock	5
le and cement rock in thin streaks	13
e white gypsum	4
le	2
ite gypsum	12
le	1
hite gypsum	4
ale and gypsum mottled	7
rab colored shale with several thin layers of hite gypsum	58
rk colored limestone	2
ale and limestone	4
mpact shale	3
psum and shale mottled and in streaks approximating	290±

f this formation has never been mined in this dis- he strong flow of water through these strata. No und in the Salina of this region, though they are f the formation farther east. Salt water is however sils are very rare throughout these beds; none have the exposures on the Niagara river.

Rondout waterlime

beds of this region grade upward into a magnesian ch contains a considerable amount of aluminium sili- per portion of this series, which in the Niagara region ss of about 50 feet, is very uniform in character and ne manufacture of hydraulic cement. In North Buf- quarries have been opened in this rock by the Buffalo cement co., and here a stratum nearly 6 feet thick is quarried and converted into cement. As the quarries are opened south of the second escarpment (inface of the Onondaga cuesta[1]), the surface rock of Onondaga limestone and the Manlius limestone have to be stripped off before the cement rock is reached.

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[1] ement and gypsum deposits in Buffalo. Am. inst. min. eng. 88.

The characters of the several strata have been briefly enumerated in the section derived from the gas well core. The upper beds, which are alone accessible in this region, may generally be seen in the escarpment, specially where it is crossed by streams, as at Williamsville, or where quarries have been opened. The rock is fine grained, often showing a marked banding or lamination, and breaks with a conchoidal fracture, producing rounded surfaces.

In this rock we find entombed the remains of those remarkable crustacea, the Eurypterids, whose bizarre form, remotely fish-like, has excited more interest than any other fossil found in this region. These Crustacea have made the Waterlime of Buffalo famous, and the Buffalo society of natural sciences, whose collections embrace a magnificent series of these fossils, has fittingly adopted it as chief among its insignia.

Besides these crustacea several other organisms have been found in the Waterlime strata of north Buffalo. Among these are a number of undescribed brachiopods, including at least one species of Lingula.

Manlius limestone

The waterlime of north Buffalo is succeeded by a stratum of impure limestone from 7 to 8 feet in thickness and known locally by the name of "bullhead" rock. The line of demarkation between the two formations is not a very pronounced one, for the inferior rock grades upward into the superior one. The rock is a dolomitic limestone of a very compact semicrystalline character, with a high percent of argillaceous material, and not infrequently a strong petroleum odor. It is mottled, having frequently the appearance of a limestone breccia, and consists of purplish gray, angular or rectangular pieces and similar light colored and more yellowish ones. The latter appear to be more argillaceous than the former. There conclusive evidence that the rock is brecciated, nevertheless oloration strongly suggests it.

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[1] *See* chapter 1.

is rock is commonly very porous in its upper portion, the ies being often lined with crystals of calcite or other minerals. smaller of the cavities are due to the dissolving out of the small Cyathophyllum hydraulicum, which was exngly abundant in the upper part of the stratum. This coral is rally found in a prostrate position, with the mold perfectly pre-ed in the inclosing rock matrix, so that a perfect cast of the can be obtained by the use of gutta percha or dentist's wax. est exposure of this rock is in the walls of the quarries of the alo cement co. It may also be seen in the face of the Onon- escarpment at Williamsville and eastward. In many places in ement quarries, the upper part of this limestone is rich in iron rites, which commonly occurs in small cubes, not infrequently idized to limonite. Green stains of hydrous carbonate of copper, malachite, are not uncommon, these resulting probably from the composition of chalcopyrite, which is disseminated in minute rains through portions of the rock. Many of the geode cavities ntain scalenohedra or acute rhombohedra of calcite, as well as sul-te of strontian.

A remarkable feature of the Manlius limestone of the Niagara re-ion is the nature of the fossil fauna which it contains. This fauna ows an intimate relation to the Coralline limestone fauna of Scho-rie county (N. Y.) a rock which is regarded the eastern equiva-nt of the Lockport (Niagara) limestone of this region. Several the species found in the Manlius limestone of this region are lentical with those of the Coralline limestone, while between other epresentative species of the two formations there exists a very close elationship. It is difficult to escape the conclusion that the Man-ius limestone fauna of the Niagara region is a late return of the Coralline limestone fauna, at the close of the long interval during which the Salina shales were deposited in the Siluric seas of this region.

The Siluro-Devonic contact

The Manlius limestone of the Niagara region is succeeded by the Onondaga limestone of Devonic age. The latter rests unconformably on the former, this unconformity being emphasized by the absence of all Lower Devonic strata in this region, with the exception of thin lenses of sandstone which may be correlated with the Oriskany. The upper surface of the Manlius limestone is knotty and concretionary, producing minor irregularities, but in addition to these there are well marked traces of the erosion of these strata, prior to the deposition of the overlying beds. These traces are of the nature of channels and irregular truncations of the strata, the former in some cases assuming considerable importance. (Fig. 21-23)

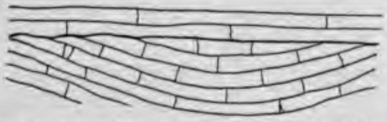

Fig. 21 Unconformable contact between Manlius and Onondaga limestones, Buffalo cement quarry.

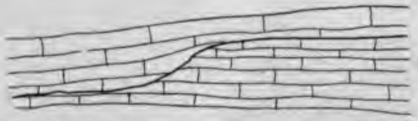

Fig. 22 Erosion of Manlius limestone prior to deposition of Onondaga limestone, Buffalo cement quarry.

In the east wall of the quarry, not far from the stamp mill, the surface of the Manlius limestone is strongly excavated, the excavation being mainly filled by beds of the Onondaga limestone. Between the two limestones occurs a mass of shale and conglomerate having a total thickness, in the central portion, of something over a foot. The lower 6 or 8 inches are a limestone conglomerate, the pebbles of which are fragments of the underlying limestones. These pebbles are flat, but well rounded on the margins, showing evidence of protracted wear. They are firmly embedded in a matrix of indurated quartz sand, which surrounds them and fills in all the interstices. This bed thins out toward the sides of the channel. On the conglomerate lie about 6 inches of shale and shaly limestone, and these are succeeded by the Onondaga limestone. The width of the channel, which is clearly an erosion channel, is about 18 feet, and its depth is about 3½ feet. (Fig. 23)

From the point where this channel is seen, the contact can be traced continuously for a thousand feet or more eastward, along the quarry wall. It frequently shows a thin shaly bed, often containing quartz grains, lying between the two limestones.

Not very far from the channel just described, a remarkable "sandstone dike" penetrates the Siluric limestones of the quarry wall.

This dike, which can be clearly traced in the wall of the quarry for a distance of perhaps 30 feet in an east and west direction, was caused by the filling of an ancient fissure in the Siluric strata, by sands forcibly injected from above. The fissure had a total depth of about 10 feet; its walls were very irregular, and at intervals lateral fissures extended in both directions. (*See* Fig. 24) All of these are now filled with pure quartz sand, firmly united into a quartzose sandstone by the deposition of additional silica in the interstices between the sand grains.

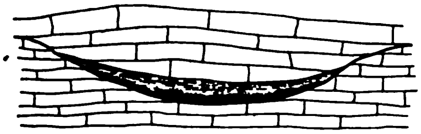

Fig. 23 Channel in Manlius limestone with Oriskany sandstone and conglomerate layers, capped by Onondaga limestone, Buffalo cement quarry.

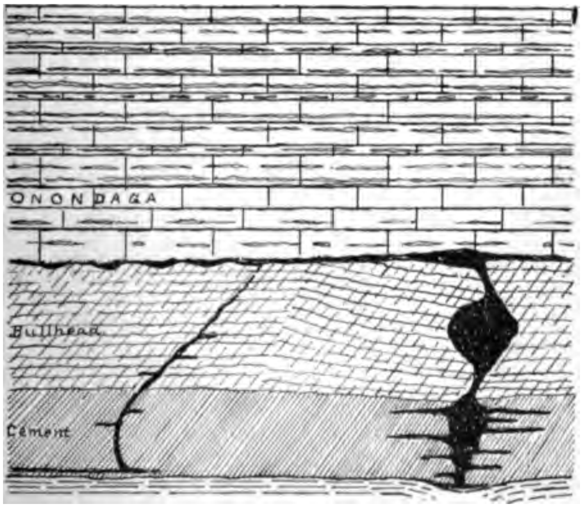

Fig. 24 Sandstone dike in the Siluric strata of the Buffalo cement quarries. (After Clarke)

The dike penetrates the "bullhead" rock and enters the waterlime to a depth of from 2 to 3 feet. It is squarely cut off at the top, where the Onondaga limestone rests on its truncated end and on the limestone flanking it. The Onondaga limestone is entirely unaffected by the dike, being evidently deposited after the formation and truncation of this remarkable mass of sandstone. The width of the filled fissure is scarcely anywhere over 2 feet, but the lateral offshoots extend many feet into the walls of Manlius limestone. These offshoots or rootlets of the dike are irregular, commonly narrow, and often appear as isolated quartz masses in the Manlius or the waterlime rock, the connection with the main dike not being always discernible. Such masses of quartz sandstone have been traced for more than 30 feet from the dike. The irregularity of the walls of the fissure is very pronounced. Angular masses of limestone project into the quartz rock, while narrow tongues of sandstone everywhere enter the limestone. Extensive brecciation of the limestone has occurred along the margin, and the sandstone there is filled with angular fragments of the limestone, which show no traces of solution or wear by running water. These limestone fragments are themselves frequently injected with tongues of the quartz sand. Microscopic examination shows evidence of a certain amount of shearing along the margin of the dike, accompanied by a pulverizing or trituration of the limestone, and followed by reconsolidation. These and other features point to a cataclysmic origin of the fissure which contains the dike and a more or less violent injection of the sand. The fissure must have been formed and filled before the deposition of the Onondaga limestone and while the Manlius limestone was covered by a stratum of unconsolidated sand. The formation of the fissure and the injection of the sand into it from above must have occurred simultaneously; for this appears the only way to account for the inclusion of large fragments, or "horses", of the wall rock in the loose sand, and the injection of the sand into all the cracks and crevices. It seems probable that the fissure records an earthquake shock during the period intervening between the close of the Siluric age and the deposition of the Devonic limestones. This is borne out by the occurrence of numerous small faults or displacements in the underlying strata of waterlime.

Devonic strata

The Lower Devonic is represented in the Niagara region by the thin beds of shale and sandstone before mentioned as occupying erosion hollows in the Manlius limestone. These are perhaps the equivalent of the Oriskany sandstone of eastern New York, though no fossils have been found in them. With the exception of these layers the Lower Devonic strata are wanting in this region.

The Middle Devonic is however well represented in the Niagara region by the Onondaga limestone. This rock, which, as has been shown, rests in most cases directly on the Manlius limestone, consists of a lower crystalline and highly fossiliferous portion, and an upper mass full of layers of hornstone or chert which on weathered surfaces stand out in relief. This part of the formation is generally known as the Corniferous limestone, in reference to the layers of chert which make the rock unfit for other use than rough building. Owing to the presence of the hornstone, this rock effectually resists the attacks of the atmosphere, and hence its line of outcrop is generally marked by a prominent topographic relief feature, the second escarpment of western New York i. e. the inface of the Onondaga cuesta.

The chert-free lower member of this formation varies greatly in thickness even within a limited territory. It is in places extremely rich in corals, and outcrops of this rock show all the characteristics of an ancient coral reef.

History of the Niagara region during Siluric time

We have now gathered data for a brief synopsis of the history of this region during Siluric time. Much still remains to be learned, but from what is known we can trace at least in outline the sequence of geologic events which characterized that ancient era of the earth's history in this vicinity.

When the Siluric era opened, New York, with portions of Pennsylvania and southern Ontario, was covered by the shallow Medina sea. This sea appears to have been of the nature of a mediterranean body of water, which later changed to a bay opening toward the southwest. This "Bay of New York", as we shall call it, came into existence by the orogenic disturbances which marked the transition from the Ordovicic to the Siluric era, and as a result of which the Taconic mountain range, with the Green mountains and the corresponding Canadian ranges, were elevated. This cut off the communication between the open Atlantic and the interior Paleozoic sea which existed during Ordovicic time. This bay was thus surrounded by old-lands on the north, east and southeast, and its waters appear to have been very shallow. We do not know just what the conditions were under which the early Siluric deposits of this region were made; for the lower beds are so barren of organic remains, that we are forced to look for evidences other than that furnished by fossils, of the physical conditions during this period. It is not improbable that the waters of the early Medina sea were cut off from the ocean at large, at least sufficiently to prevent a free communication. This may not have been the case at first; for Arthrophycus harlani flourished in these waters during the deposition of the Oswego beds,[1] and this species characterizes the rocks of late Medina age, during the deposition of which we have reason to suppose that a junction of the Medina sea with the ocean at large had been effected.

Along the eastern and southeastern margin of this interior water body were deposited the thick beds of conglomerate, which now constitute the capping rock of the Shawangunk and other ranges of hills, while farther west, at a distance from the source of supply, the Oswego sandstone was accumulating. Later the character of the deposit changed in this region, from the gray silicious sands to the impalpable muds and fine sands of the lower Medina. Whatever the source of these sands, ferruginous matter was plentiful, as shown by the red color of the deposits, and this leads to the supposition that they were derived from the crystalline rocks of the Adirondacks and the Canadian highlands and not from Ordovicic or Cambric deposits.

It is not improbable that, during the early Medina epoch, the waters of this basin were of a highly saline character. No deposits of salt were formed, or if these existed, they were subsequently leached out. The Medina beds are however rich in saline waters, salt springs being common throughout this region,[2] and this may indicate a high degree of salinity of the waters of the early Medina sea. If such was the case, it may have been accompanied by a more or less arid climate, which favored the concentration of the sea water. Thick beds of terrigenous material accumulated in the center of the Medina basin reaching in the Niagara region a thickness of over a thousand feet. These early deposits probably did not extend far west for, though in northern Ohio and Michigan, Medina beds from 50 to 100 feet or more in thickness are known, these are probably to be correlated with the upper Medina of the Niagara region.

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[1] This species is found in the eastern part of the district, at the base of the Oneida conglomerate.

[2] In the early part of the century salt was not infrequently manufactured from these springs.

Toward the close of the Medina epoch, the Siluric sea had encroached on the lands to such an extent as to effect a junction with the Medina basin, whereupon normal marine conditions were again established. This is indicated by the marine fauna and flora which characterize the upper Medina beds. The first deposit in this region, on the reestablishment of normal marine conditions, was the white quartzose sandstone which caps the red shale of the lower series. Mud and sand now alternated, indicating an oscillation of conditions with numerous changes in the currents which distributed the detrital material. Thin beds of limestones also formed at rare intervals, chiefly from the growth of bryozoans in favorable localities. In the Bay of New York the waters continued moderately shallow, as shown by the well developed cross-bedding structure in the sandstones. At intervals large tracts seem to have been laid bare on the retreat of the tide, as indicated by the wave marks and other shore features which give the surfaces of some Medina sandstone slabs such a remarkable resemblance to a modern sand beach exposed by the ebbing tide. In fact, we may not inaptly compare this stage of the Siluric bay of New York with the upper end of the modern bay of Fundy, where the red sands and muds are laid bare for miles on the retreat of the tide.

After the last sandstone bed of the Medina stage had been deposited, the water probably became purer and deeper, and the 6 feet of Clinton shales were laid down in the Niagara region. In the eastern part of the Bay of New York, sandstones were deposited even during the Clinton epoch, while the conditions favoring the deposition of limestone existed only during the short interval in the Niagara period, when the Coralline limestone of Schoharie was laid down. Westward, however, the adjustment of conditions went on more rapidly, and the Clinton limestones, with the calcareous shales and limestones of the upper Niagaran, became the characteristic deposits. During nearly the entire Niagara period life was abundant in the Siluric sea, and the Bay of New York had its marvelous succession of faunas, which have made these strata the standard for the Siluric beds of this continent.

All the Siluric limestones of the Niagara section show characters pointing to a fragmental origin, and in this respect they contrast strongly with the Devonic limestones in the southern part of the district. The latter, as before mentioned, show the characteristics of an ancient coral reef, and we may therefore assume that they were built up in situ by the polyps and other lime-secreting organisms. Not so with the Siluric limestones. These, to be sure, were derived from similar deposits by lime-secreting organisms, but these deposits were originally made in a different place from that in which we find the limestones today. A sedimentary limestone or lime-sandstone is similar to a quartz sandstone or a shale, in that the material of which it is formed is the product of erosion of preexisting rocks. In the case of the quartz sandstone, this is generally an inorganically formed rock, while the sedimentary limestones are most usually derived from organically formed rocks. In the former case, the source of the material is often a distant one, while in the latter it is generally, though not necessarily always, close at hand. A coral reef growing in moderately shallow water is attacked by the waves, as are all rocks which come within their reach. Erosion results, and the product of this activity is carried away and deposited on the ocean floor as a calcareous sand. Thus stratified deposits of limestones are formed, whereas in the original organic reef, no stratification is to be expected. In the immediate neighborhood of the growing reef, the beds of calcareous sand will slowly envelop the original deposit from which they were derived, and thus the source of supply is chiefly the upper growing portion of the reef. On the lime-sandstone strata which flank the reef, independent masses of coral may at times grow, while other organisms, such as mollusks and brachiopods, will also find this a convenient resting place. Thus the organically formed limestone masses and the fragmental limestones will interlock and overlap each other around the borders of a growing reef. It follows then that in the neighborhood of the growing coral masses the sands derived from their destruction will be coarser, the finer material being carried farther out to sea, and deposited at a distance from the source. Thus an approximate criterion for the determination of the distance of any given bed of calcareous sand from its place of origin is furnished. If deposits of such calcareous sand are made in shallow water, cross-bedding and ripple marks will be found just as in the quartz sands, and, as we have seen, the former structure is characteristic of most of the strata of Lockport limestone exposed in the gorge section at Niagara. It may be added that, as the organic limestone will continue to form as long as the conditions are favorable, the supply of calcareous sand is practically inexhaustible. Hence thick beds of such lime-sandstones may form.

In the Niagaran seas the chief reef-building corals were Favosites, Halysites and Heliolites, together with the hydro-coralline Stromatopora. Bryozoans also added largely to the supply of organically formed limestone of the various reefs. But perhaps the most important contributors in this connection were the crinoids and related organisms, which may at times have constituted reefs of their own. Their abundance is testified to by the frequent thick beds of limestone, which are almost wholly made up of broken and worn crinoid fragments. The crinoids fell an easy prey to the waves, for, on the death of the animal, the calyx, arms and stem would quickly fall apart into their component sections, and hence yield fragments readily transported by the waves. In the case of the corals and the shells, which latter probably formed no unimportant part of the organic contributions to the reefs, the work of grinding the solid limestone masses into a sand probably required the aid of tools, such as large blocks that could be rolled about by the waves, or it may have been aided by the omnipresent reef-destroying organisms.

The infrequency of exposure of the fossil reefs, which furnished the calcareous sand, need not disturb us. We must remember that the actually exposed sections of these limestone strata are very few when compared with the great extent of the beds themselves. It must also be borne in mind, that vast portions of these limestone beds have been removed by erosion during the long post-Siluric time. When we realize that the actual reefs must have been widely scattered in the Niagara sea, and that our sections through these strata are random sections, we need feel no surprise at the unsatisfactory character of these exposures. It must however be added that sections farther east, as at Lockport or other localities, generally show much more of the reef character of the deposit, the corals in these being correspondingly abundant. The upper geodiferous beds of the limestone at Niagara were probably much more fossiliferous than the lower. As before mentioned, the geode cavities most likely are the result of alteration or solution of some fossil body, probably a coral. Though fossils may have been plentiful, none of these beds, so far as examined, show the characteristics of true reefs. They have more the aspect of beds of coral sand, on which isolated heads of corals and other organisms grew rather plentifully.

During the dolomitization of these limestone beds, which was probably brought about by chemical substitution before the consolidation of the coral sand, many of the fossils which were included in these sands probably suffered alteration and more or less complete destruction. Thus it will be seen that even the few organisms which were embedded in these coral sands, did not survive the subsequent changes, and thus the barrenness of these great limestone masses appears to be fully accounted for. The fossiliferous character of the upper Clinton limestone, as well as the coarseness of the calcareous fragments of which it is composed, points to a nearness of this rock to the source of the material; for in the vicinity of the coral and crinoid reefs the food supply for other organisms would be most abundant, and hence these would develop most prolifically in such a neighborhood.

A careful comparative study of the Niagaran deposits of New York and those of the middle states has brought out some important and interesting facts. These may be summed up in the statement, that the New York fauna is more individualized, showing characteristics stamping it in some degree as a provincial fauna. The Niagaran fauna of the central states however is more closely allied to the European Mid-Siluric fauna than to that of New York state, from which we may conclude that the pathway of communication between the American and European Siluric seas was not by way of New York, a conclusion which is in entire harmony with those derived from the physical development of this region and the characteristics of the strata.

Weller[1] has collected data which indicate that the pathway of migration of faunas between the two continents was by way of the arctic region. According to Weller's interpretation of the facts, there existed in North America during Siluric time ". . . a north polar sea with a great tongue stretching southward through Hudson bay to about latitude 33°. There were doubtless islands standing above sealevel within this great epicontinental sea; and at the latitude of New York there was a bay reaching to the eastward, in which the Siluric sediments of the New York system were deposited. Labrador, Greenland and Scandinavia were in a measure joined into one great land area, though perhaps with its continuity broken, with a sea shelf lying to the north of it and another to the south. Another epicontinental tongue of this northern sea extended south into Europe, bending to the west around the southern part of the Scandinavian land and connecting with a Silurian Atlantic ocean. The sea shelf to the north of the Labrador-Scandinavian land was a means of intercommunication between northern Europe and the interior of North America, and the sea shelf to the south of this land was a pathway between England and eastern Canada." That portion of North America lying to the west of a line drawn from the Mississippi to the Mackenzie appears to have been dry land during the Niagara period, and connected with the Appalachian land on the east by the westward trending axis of the latter in the southern United States.

At the close of the Niagara period, there appears to have been an elevation of the continent which converted the Bay of New York and the greater part of the interior Siluric sea into a vast partially or entirely inclosed basin. This elevation appears to have been accompanied by climatic desiccation which brought about a rapid evaporation of the waters and a consequent increase in salinity. Thus this great interior water body was changed from a richly peopled mediterranean, to a lifeless body of intensely saline water, a veritable Dead sea. As the concentration of the brine continued, deposition of gypsum began, and later on the extensive beds of rock salt of this formation were laid down. Some of these salt beds in Michigan are reported to be a thousand feet thick, but none of the New York beds approach this thickness. The clastic strata of the Salina series were probably derived from the destruction of the sediments which were formed during the early periods of the Siluric and during preceding periods. This would account for the presence of limestone beds in deposits formed in a lifeless sea. All these limestones were more or less mixed with clayey sediments; they may in fact be regarded as consolidated argillo-calcareous muds derived from older limestones and shales. This is the character of the Waterlime and Manlius limestone which succeed the Salina beds, and which, though fossiliferous, could have no other source of origin than preexisting limestone beds.

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[1] Nat. hist. sur. Chicago acad. sci. bul. 4 and Jour. geol. 4:692-703.

The Waterlime has been regarded as a fresh-water formation. It is more likely however that it represents a return of marine conditions through the opening of channels between this interior basin and the ocean at large. This is indicated by the fauna, which includes undoubted marine forms. Whether this connection was through the old northern channel, or whether a new channel toward the east was opened is not apparent. The former is indicated by the character of the Manlius limestone which succeeds the Waterlime, and which in the Niagara region has features associating it with the corresponding deposits of Ohio, Michigan and Ontario, rather than its eastern equivalents. Whatever the nature of the transgression of the sea which took place in the late Siluric, it was not of long duration. The epoch of the Manlius limestone and with it the Siluric era were brought to a close with the withdrawal of all the waters from this portion of the continent, which thereafter for a long period of time remained above the sea. During this time, the Helderbergian and other Lower Devonic strata were deposited in the Appalachian region, which by that time had established a southern connection with the open Atlantic.

Finally, toward the middle of the Devonic era, the sea once more transgressed on the abandoned continent, and again all this region was covered by oceanic waters. On the land surface of early Devonic times, now grew corals in great luxuriance; and reefs of great extent, with their accompanying deposits of coral sands, and their wealth of new life, again characterized the interior Paleozoic sea. It was not till long ages after, that this portion of the continent was again raised above the sea. This last elevation, which took place toward the close of Paleozoic time, was a permanent one, with the exception of a possible slight resubmergence of some parts of this region after the close of the glacial period. With the last great emergence of the land were inaugurated those long cycles of erosion outlined in chapter 1, which resulted in the formation of the great topographic features of this region, and which came to a close only with the envelopment of this region in the snow and ice of the great glacial winter.

Chapter 4

FOSSILS OF THE NIAGARA REGION[1]

PLANTS

The Paleozoic marine plants or seaweeds are generally classed together as "fucoids", a term denoting a relation of these organisms to the modern rockweed, Fucus, which fringes the rocks of our seacoast. These plants were probably algae, but it is impossible in most cases to make a more precise classification. The condition in which these remains are found today—as a rule mere impressions or casts of the original—generally renders the determination of their affinities a hopeless task. In some remains the plant nature of the organism is even questionable.

Genus BYTHOTREPHIS Hall

[Ety.: βυθοτρεφής, growing in the deep]

(1847. *Pal. N. Y.* 1:8)

Plant consisting of subcylindric or compressed stems, usually flattened on the rock surfaces and having numerous spreading branches, which in some species are leaf-like.

Bythotrephis gracilis Hall (Fig. 25) (1852. *Pal. N. Y* 2:18, pl. 5)

Distinguishing characters. Slender branches diverging at varying angles from a central stipe which not infrequently bifurcates. Terminations of branches round to pointed.

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[1] In this chapter only the Siluric fossils of the Niagara region will be considered, those of the Devonic limestones, which border this region on the south being so numerous that they must be reserved for a future publication. No attempt is made to add to the number of known species of Siluric fossils of the Niagara region. Of described species those only which have been found in this region or recorded in the literature as coming from it have been included, with the addition of such species from neighboring localities as occur there abundantly, and may reasonably be expected to occur in the Niagara sections. An exhaustive study of the Niagara fauna of western New York has still to be made. In chapter 5 a complete account of all the post-Pliocene shells so far found in the Niagara gravels is given, this being the first time that these shells are described and illustrated.

These organisms occur as mere impressions on the rock surfaces, varying in slenderness of branches from less than 1 mm to 5 mm (varieties intermedia and crassa).

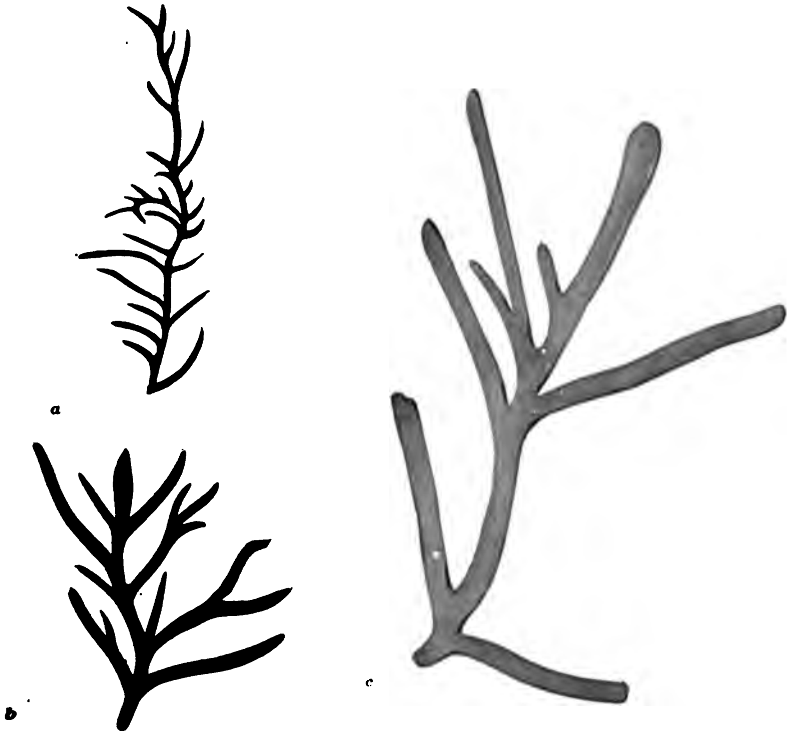


Fig. 25 Bythotrephis gracilis; showing varieties. *a* B. gracilis; *b* B. gracilis var. intermedia; *c* B. gracilis var. crassa

Found in the shaly partings separating the thin beds of the lower Clinton limestone at Niagara.

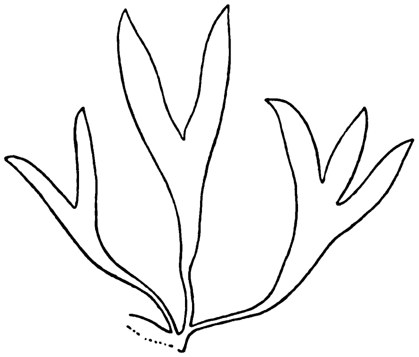


Fig. 26 Bythotrephis lesquereuxi

Bythotrephis lesquereuxi Grote & Pitt (Fig. 26) (1876. *Buffalo soc. nat. sci. Bul.* 3:88, 4:20, fig. 6)

Distinguishing characters. Flattened, erect stem; simple, sparingly dichotomous branches, 3-4 mm thick, gradually widening to nearly 1 cm at the very obtuse or round truncate point;

smooth surface; branches mostly simple from the base 13-14 cm long.

Found in the cement beds of the Waterlime, Buffalo (N. Y.) (Grote & Pitt)

Genus ARTHROPHYCUS Hall

[Ety.: ἄρθρον, a joint; φῦκος, a seaweed]

(1852. *Pal. N. Y.* 2:4)

Stems simple or dividing at the beginning and remaining simple thereafter; rounded or subangular, flexuous, transversely marked by ridges or articulations.

Arthrophycus harlani (Conrad) (Plate 16) (1852. *Pal. N. Y.* 2:5, pl. 1 and 2)

Distinguishing characters. Strong, rounded articulated stems, dividing near the base into numerous elongated branches; simple, flexible, articulated branches which diminish in size very gradually.

Found on the under side of certain sandstone beds in the upper part of the Medina in the Niagara section.

Genus NEMATOPHYCUS Carruthers

[Ety.: νῆμα, thread; φῦκος, seaweed]

(1872. *Month. micro. jour.*)

Considered a gigantic alga, with cylindric branching stems, and a peculiar structure which led Dawson to refer it to the Coniferae under the name Prototaxites. What resemble concentric rings of growth and medullary rays appear; cells irregular, cylindric, thick walled. The specimens are generally silicified.

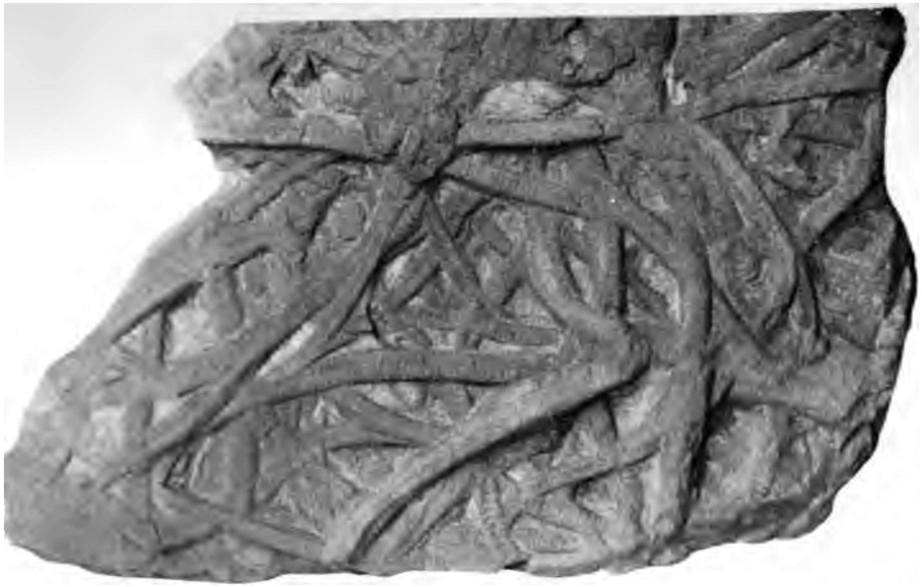
Nematophycus crassus (Penhallow) (1896. Nematophyton crassum Penhallow. *Can. record of science.* July 1896, 7:151-56, pl. 2)

Distinguishing characters. Section showing numerous irregular round or oval medullary spots; large cells in groups, thick walled.

The specimen is the basal portion of a stock showing root processes; length 56 cm, diameter at upper end 7.5 cm, widening toward base to 16.5 cm.

Found in the Manlius limestone of North Buffalo. (F. K. Mixer)

Plate 16



Arthrophycus harlani Conrad; upper Medina sandstone. Slightly reduced (original)

ANIMALS

Class HYDROZOA Owen

This class includes the simplest polyps, of which the fresh-water Hydra is an example. The body consists of a hollow tube, the walls of which are composed of two cellular layers, *ectoderm* and *endoderm*, with a non-cellular layer, the *mesogloea*, between them. These layers meet at the mouth, which is the only opening into the gastric space inclosed by the body wall. Tentacles, furnished with nettle cells, surround the mouth.

A few hydroids are simple forms, but the majority are united into colonies, which frequently assume a branching or tree-like character, a polyp occupying the end of each branch. Reproduction is usually carried on by specially modified polyps, the *gonopolyps*, which produce jellyfish or medusae. These may remain attached to the colony or become free-swimming.

Some hydroids are entirely unprotected, no hard structures being developed, and these consequently leave no remains. The majority of species, however, secrete a horny or chitinous covering, the *periderm*, which invests the whole stock, and in one group is expanded at the ends of the branches into cups or *hydrothecae*, into which the polyps can withdraw. This chitinous periderm may be preserved in the form of a carbonaceous film (e. g. Dictyonema and Graptolites).

Some hydroid colonies, i. e. the hydrocorallines, secrete at the base a dense calcareous covering, which has much the aspect of coral, and is frequently mistaken for that (e. g. Millepora, Stromatopora). Most hydroid colonies are permanently attached to rocks, seaweeds, or other objects of support.

Genus DICTYONEMA Hall

[Ety.: *δίκτυον*, net ; *νῆμα*, thread]

(1852. *Pal. N. Y.* 2:174)

Colony forming a network of anastomosing branches, the whole commonly flattened on the rock surface, but originally forming a funnel or fan-shaped expansion. The branches proceed from a common acute base, divide frequently, and are at intervals united again by transverse dissepiments. The outer surfaces of the branches are striated; the inner bear hydrothecae, though these are seldom seen in the flattened specimens.

Dictyonema retiforme Hall. (Fig. 27) (1852. *Pal. N. Y.* 2:174, pl. 40F)

Distinguishing characters. Form circular or cup-shaped in growing state; thin, flat, frequently bifurcating branches, united laterally by obliquely transverse filaments, leaving oblong quadrangular interstices; indented or obliquely and intermittently striated surfaces.

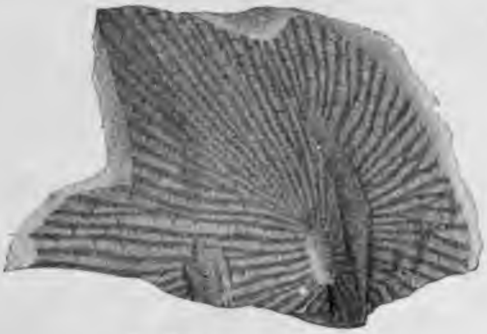


Fig. 27 Dictyonema retiforme

Found rarely in the lower part of the Rochester shales in the Niagara section; usually fragmentary. Abundant at Lockport and elsewhere. (Hall)

Genus STROMATOPORA Goldfuss

[Ety.: *στρῶμα*, a covering; *πόρος*, a pore]

(1826. *Petrefacta Germaniae*, p. 22)

Skeleton forming hemispheric, globular or expanded masses composed of numerous concentric, undulating calcareous laminae, separated by interspaces, and connected by radial pillars which unite with the thick concentric laminae and form a finely reticulate tissue, visible in cross-section. Traversing the entire mass are sparsely scattered tubes which are divided by numerous tabulae or horizontal floors, and were occupied by the larger polyps of the colony. Base of entire skeleton covered by a wrinkled " epitheca ".

Stromatopora concentrica Goldfuss Hall (Fig. 28) (1852, *Pal. N. Y.* 2:136, pl. 37)

Distinguishing characters. Hemispheric or spheroidal form sometimes irregular; thin concentric laminae, readily visible in weathered specimens, and scarcely of the thickness of writing paper; surface of laminae marked by fine pores.

This coralline is generally very massive and may attain a diameter of 2 feet. Probably includes a number of distinct species.

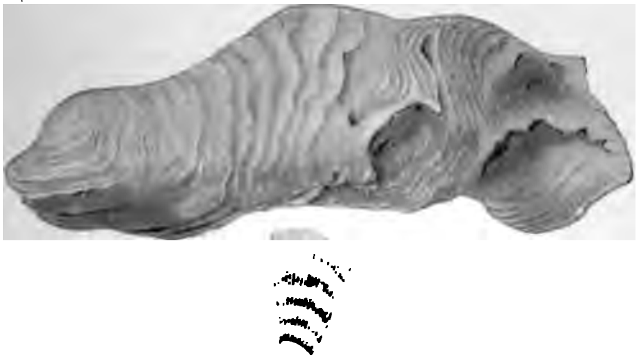


Fig. 28 Stromatopora concentrica Hall with an enlargement of a cross-section

Found at Niagara in the Lockport limestone, particularly the geodiferous beds, and generally common throughout the middle limestones. Also at Lockport and elsewhere.

Class ANTHOZOA Ehrenberg

The Anthozoa, or coral polyps, are marine animals ranging from low water to 300 and sometimes even 1500 fathoms (Zittel). The reef-building types however do not flourish in depths greater than 50 fathoms, and are generally restricted to 20 fathoms or less. Both simple and colonial forms occur, the latter predominating at the present time, while the former were abundant in the Paleozoic. The two important types of Paleozoic corals are the "rugose corals" or Tetracoralla, and the tabulate corals, the former generally simple, the latter colonial types.[1]

The simple rugose corallum is well represented by **Enterolasma**. It consists of numerous radiating *septa*, disposed in several cycles, and united round their outer margins by a wall or *theca* (*pseudotheca*). This is formed by the lateral expansion or thickening of the septa in that region. The exothecal prolongations of the septa are visible on the exterior of the corrallum as costae, which are frequently represented by grooves instead of ridges. These, in the genus referred to, as well as in others, commonly show the peculiar tetrameral arrangement characteristic of the septa of this group. On or near the convex longitudinal surface of the corallum a median, or " cardinal ", septum appears, from which the secondary septa pass off in a pinnate manner (fig. 29). 90° toward either side occur the "alar" septa. These are parallel[1] to the secondary septa which branch off from the cardinal septum. They have a single series of secondary septa branching off from them on the side away from the *cardinal quadrants*. The two remaining, or *counter quadrants*, are filled with parallel septa, which branch off, in a pinnate manner, from the alar septa, and are completed in front by the *counter septum* to which they are all parallel.

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[1] As no true Hexacoralla occur in the formations treated of in these pages, an account of their structure is omitted.

One of the four "primary septa"—commonly the cardinal septum—may be aborted, leaving a groove or *fossula*. Between the septa various endothecal tissues may be developed, such as cross plates, or *dissepiments* connecting adjoining septa; *tabulae*, or floors more or less completely dividing the whole inner space, irrespective of the septa; and *cysts*, which form a vesicular tissue more or less regularly disposed (Cystiphyllum). The cup or calyx may be limited below by a continuous floor, by dissepiments or otherwise, or it may be limited only by the margins of the septa, the spaces between the septa being open to the bottom of the corallum. The costae are commonly covered by a concentrically wrinkled *epitheca*, which forms the outermost wall of the corallum.

In colonial forms the adjacent corallites commonly become prismatic from crowding. The separate thecae may be retained, or they may become obsolete, the corallites becoming confluent. The epithecal covering in these forms is commonly confined to the free margins of the outer corallites, and surrounds the whole colony as a *peritheca*.

The tabulate corals are invariably compound, either loosely or compactly, and consist of tubular or prismatic corallites commonly with thick walls, which in certain groups are perforated by *mural pores*. Septa are absent or but slightly developed, sometimes being represented merely by vertical ridges or rows of spines. The number is usually six or 12. The corallites are crossed by numerous *tabulae* which cut off the empty portion of the tube below the polypite. Other endothecal structures are absent.

The reproduction of the Anthozoa is both sexual and asexual, the latter by lateral or calycinal budding, or by fission.

Genus ENTEROLASMA Simpson

[Ety.: ἔντερον, intestine; ἔλασμα, lamella]

(1900. *N. Y. state mus. Bul.* 39, p. 203)

Corallum simple, turbinate and usually straight. Septa numerous, those of the earlier cycles reaching nearly to the center, where they have projections which reach to the center, becoming much involved and forming a pseudocolumella of very peculiar appear-

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[1] Parallel as seen in the costae.

ance, somewhat resembling the convolutions of the intestine; those **of the last** cycles short; all with papillate elevations or carinae on **the sides, giving** in section a crenulate or echinate appearance. Dissepiments present. Epitheca well developed.

Enterolasma caliculus (Hall) (Fig. 29) Streptelasma caliculus Hall (1852. *Pal. N. Y.* 2:111, pl. 32)

Distinguishing characters. Turbinate, oblique or curved, more or less rapidly expanding form; moderately deep cup; septa 20 to 50, separated by a space of twice their width; well marked costal grooves which lie opposite both long and short septa; relatively thin and smooth epitheca.

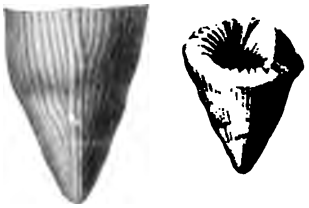

Fig. 29 Enterolasma caliculus

Found rarely in the upper Clinton beds, and abundantly in the lenses of limestone in the Clinton, the lower part of the Rochester shales and the Bryozoan beds of these shales. Also in the same shales at Lockport and farther east.

Genus ZAPHRENTIS Rafinesque

[Ety.: ζα, many; φρήν, diaphragm]

(1820. *Ann. des sci. phys.* Brux. 5:234)

Corallum simple, conic or turbinate, or conico-cylindric, with a deep calyx, and well developed septa, the primary ones reaching to the center. Dissepiments and tabulae occur, the latter usually well developed. A deep fossula marks the abortion of one of the four primary septa. Costae and a thin epitheca occur.

Zaphrentis turbinata (Hall) (Fig. 30). Polydilasma turbinatum Hall (1852. *Pal. N. Y.* 2:112, pl. 32)

Distinguishing characters. Form variable, usually short and turbinate; calyx gradually deepening from margin halfway to the center and then abruptly descending, almost vertically to a moderate depth; alternate septa terminating at point of sudden deepening of calyx, others reaching to center; dissepiments slightly developed.

Found in the Lockport limestone at Niagara(?) and Lockport, where it occurs a few feet above the shale.

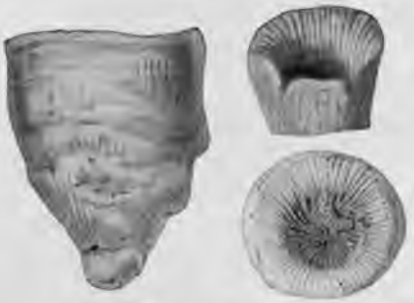

Fig. 30 Zaphrentis turbinata

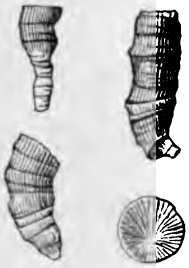

Fig. 31 Cyathophyllum hydraulicum

Genus CYATHOPHYLLUM Goldfuss

[Ety.: κύαθος, a cup; φύλλον, a leaf (septum)]

(1826. *Petrefacta Germaniae*, p. 54)

Corallum normally simple, the individuals conic, or conico-cylindric. Septa well developed, radially arranged, the larger extending to the center, where they are twisted into a pseudocolumella. Costae usually obsolete. Tabulae present but only in the center of the visceral chamber, the outer area being filled with vesicular dissepiments. Exterior covered with an epitheca.

Cyathophyllum hydraulicum Simpson. (Fig. 31) Grabau. Geol. soc. Am. Bul. 11:364, pl. 21, fig. la-d.

Distinguishing characters. Simple, conico-cylindric, slender, sometimes curved; growth irregular with abrupt changes in direction; strongly costate adult portion; non-costate young; well developed epitheca, which often shows coarse wrinkles; calyx somewhat less deep than its diameter; numerous strong thin and rather widely separated septa, meeting in center where they are slightly twisted, and not infrequently uniting before they reach the center; well developed dissepimental structures.

Found abundantly in the upper Manlius limestone of the Niagara region, but only as external molds in the limestone. Gutta percha casts however show the characters well.

Genus CHONOPHYLLUM Edwards & Haime

[Ety.: χόνος, a funnel; φύλλον, a leaf (septum)]

(1850. *British fossil corals*, p. 69)

Corallum simple, chiefly consisting of a series of funnel-shaped tabulae, set one into the other. On the surfaces of these, equally developed septal radii extend from center to circumference; no walls or columella.

Chonophyllum niagarense Hall (Fig. 32) (1852. *Pal. N. Y.* 2:114, pl. 32)

Distinguishing characters. Irregularly cylindric, elongated or subturbinate form, more or less expanding above; deep and regularly concave calyx; thin denticulate septal ridges, which are separated by a space equal to their width; rough external surface of weathered specimens.

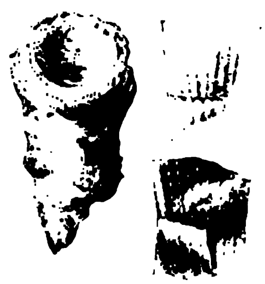

Fig. 32 Chonophyllum niagarense with enlargement of interior of calyx

Hitherto found only in the lower part of the Lockport limestone at Lockport, but probably also occuring at Niagara.

Genus DIPLOPHYLLUM Hall

[Ety.: διπλόος, double; φύλλον, septum]

(1852. *Pal. N. Y.* 2:115)

Corallum simple and branching, or forming compound masses of loosely aggregated corallites which are cylindric, consisting of two distinct parts separated by an accessory wall, the inner transversely septate, the outer with fine transverse dissepiments uniting the septa which are continuous to the center. Calyxes deeply concave in the center, and separated from the outer portion by a distinct rim.

Diplophyllum caespitosum Hall (Fig. 33) (1852. *Pal. N. Y.* 2:116, pl. 33)

Distinguishing characters. Subturbinate young, and cylindric adult corallites, which coalesce at intervals and increase by lateral budding; cespitose or aggregated into large masses which often grow from a single base; strongly costate exterior; numerous thin septa, all of which reach the center.

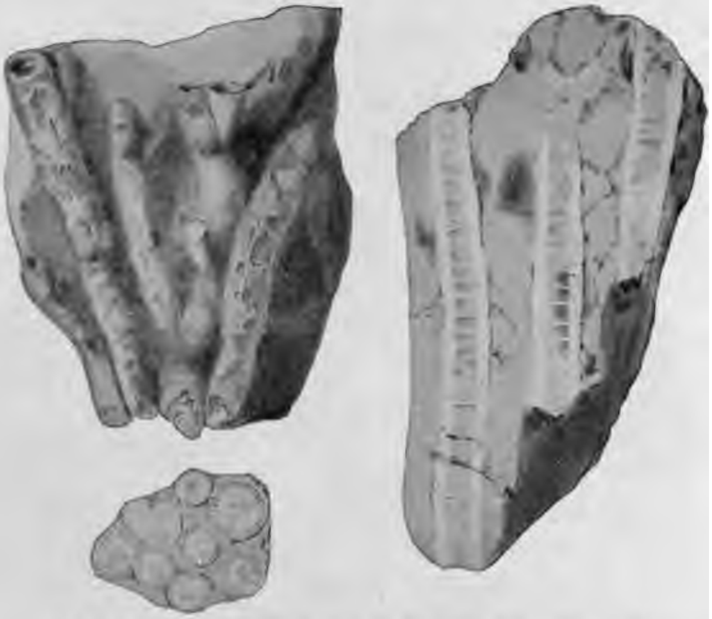

Fig. 33 Diplophyllum caespitosum with longitudinal and transverse sections

Found in the lower part of the Lockport limestone series at Lockport, and may also occur at Niagara.

Genus FAVOSITES Lamarck

[Ety.: *favus*, honeycomb]

(1816. *Hist. des anim. sans vert.* 2 :204)

Corallum massive, more rarely branching, commonly forming heads which may be a foot or more in diameter. Corallites prismatic, thin, in contact but not amalgamated by their walls, which are perforated by equidistant mural pores in one or more rows. Septa rudimentary or obsolete. Numerous more or less regular tabulae divide the intrathecal space. Peritheca present on the under side of the colony, and usually strongly wrinkled.

Favosites venustus (Hall)[1] (Fig. 34). Astrocerium venustum Hall (1852. *Pal. N. Y.* 2:120, pl. 34)

Distinguishing characters. Hemispheric or spheroidal form, beginning growth on other bodies; small corallites increasing in number by interstitial addition; 12 ascending septal spines between tabulae; corallites from .9 to 1 mm in diameter; heads often up to 2 or 3 feet in diameter.

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[1] These species are regarded by Whiteaves and Lambe as synonyms of Favosites hisingeri E. and H.

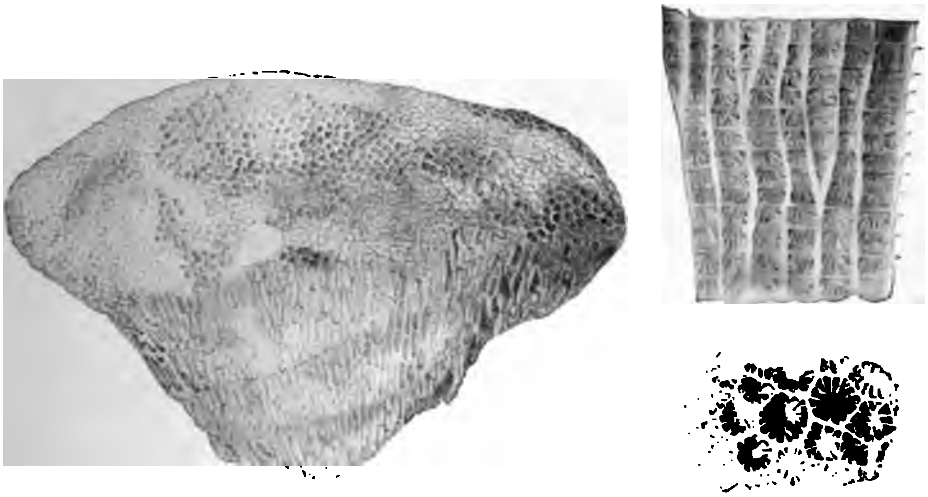

Fig. 34 Favosites venustus with longitudinal and transverse sections

Found in the Lockport limestone at Lockport and Niagara, often replaced by anhydrite or other materials.

Favosites parasiticus (Hall)[1] (Fig. 35). Astrocerium parasiticum Hall (1852. *Pal. N. Y.* 2:122, pl. 34) Not F. parasiticus Phillips.

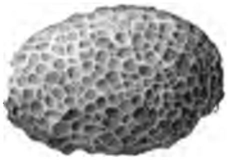

Fig. 35 Favosites parasiticus

Distinguishing characters. Hemispheric or spheroidal coralla, independent or attached to, or enveloping other bodies; unequal size of calyxes, which are stellate from septal spines, of which there are from 12 to 24; subcircular outline of some of the larger calyxes, the majority being angular.

Found in the Bryozoan bed of the Rochester shales in the Niagara sections. Also in the lower part of the limestone at Lockport (Hall).

Favosites pyriformis (Hall)[1] (Fig. 36). Astrocerium pyriforme Hall (1852. *Pal. N. Y.* 2:123, pl. 34A)

Distinguishing characters. Irregularly subturbinate, pyriform or spheroidal form of corallum; corallites radiating from a more or less extended base, spreading out above and rapidly increasing in number by interstitial addition; calyxes varying from triangular to hexagonal, not rounded and varying in size according to age of individual; septal spines in one or more rows.

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[1] These species are regarded by Whiteaves and Lambe as synonyms of Favosites hisingeri E. and H.

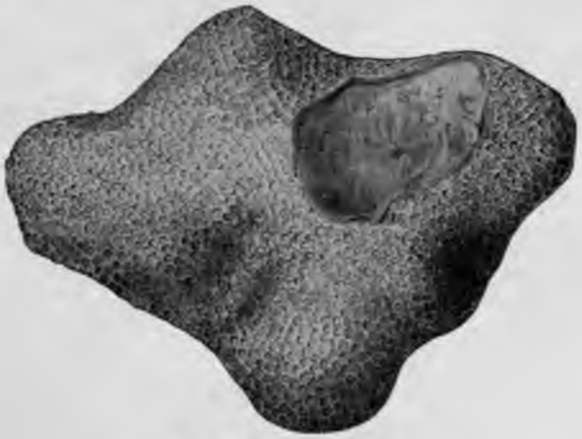


Fig. 36 Favosites pyriformis

Found in the Rochester shale and Lockport limestone at Lockport (Hall). Probably occurs also at Niagara.

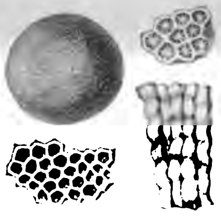


Fig. 37 Favosites constrictus; a group of corallites enlarged, and enlargements of the calyxes

Favosites constrictus (Hall) (Fig. 37). Astrocerium constrictum Hall (1852. *Pal. N. Y.* 2:123, pl. 34A)

Distinguishing characters. Small size; hemispheric form; minute corallites which appear constricted at intervals; calyxes appear stellate.

Found in the Rochester shale at Lockport and other places (Hall). Probably also at Niagara.

Favosites niagarensis Hall (Fig. 38) (1852. *Pal. N. Y.* 2:125, pl. 34A)

Distinguishing characters. Spheroidal to irregular form, rapidly increasing in size by interstitial addition of corallites; thin walled corallites with mural pores in double rows; tabulae often oblique or bent downward; calyxes varying in size with varying age of individual; septal spines obsolete.

Found in the Lockport limestone at Niagara and Lockport.

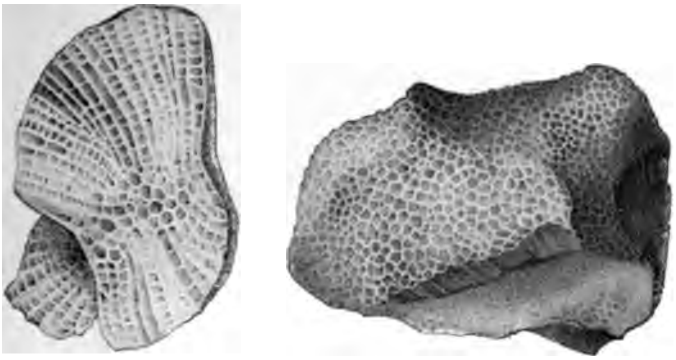


Fig. 38 Favosites niagarensis

Genus HALYSITES Fischer

[Ety.: ἅλυσις, a chain]

(1813. *Zoognosia.* 3d ed. t. 1, p. 387)

Corallum forming a clustered and reticulated mass, composed of long tubular, cylindric or compressed corallites, which are placed side by side in intersecting and anastomosing laminae or lines, any given corallite being united along its whole length with its neighbors to the right and left, and each lamina of the corallum consisting of no more than a single linear series of tubes. Walls of the corallites strong and without pores, the free portions covered by a continuous thick epitheca showing lines of growth. Small corallites often alternate with the larger ones. Septa obsolete or represented by vertical rows of spines in cycles of 12. Tabulae well developed, complete and simple, more numerous in the smaller corallites.

Halysites catenulatus (Linn.) (Fig. 39). Catenipora escharoides (Lamarck) Hall (1852. *Pal. N. Y.* 2:127, pl. 35)

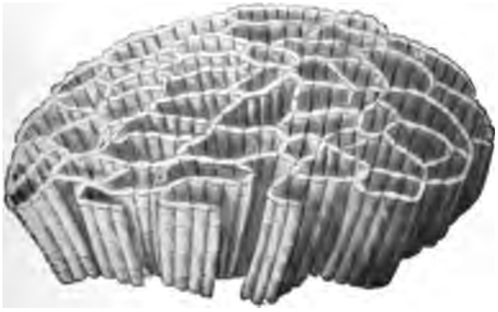


Fig. 39 Halysites catenulatus

Distinguishing characters. Corallites in juxtaposition or separated by cellular interspaces; large meshes of the network irregular, greatly varying in size; corallites oval in cross-section, united by their narrower sides; epitheca with fine lines of growth and occasionally strong wrinkles.

Found in the Lockport limestone at Lockport (Hall), and Niagara. When silicified, the coral may be well preserved, but otherwise it is usually almost destroyed or replaced by various minerals.

Genus HELIOLITES Guettard

[Ety.: ἥλιος, the sun; λίθος, a stone]

(1770. *Mem.* 3:454)

Corallum spheroidal, pyriform, hemispheric, or rarely ramose. Corallites (macrocorallites) cylindric, comparatively few in number and furnished with 12 lamellar infoldings of the wall, or pseudosepta. Smaller corallites (microcorallites) completely investing the larger ones, more or less regularly polygonal in form, with distinct walls, completely amalgamated with one another and with the walls of the larger corallites. Mural pores absent. Both kinds of corallites with tabulae, most numerous in the smaller corallites. Base of corallum covered by a peritheca showing lines of growth.

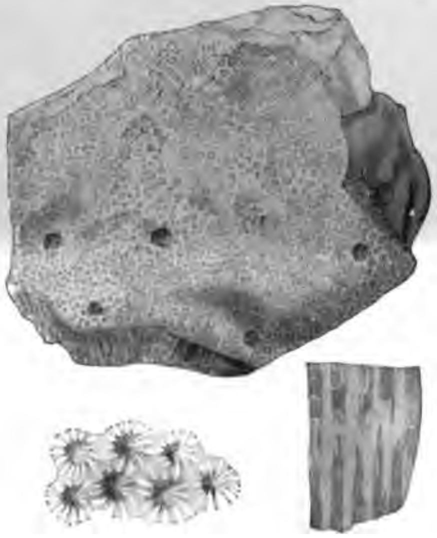


Fig. 40 Heliolites elegans with enlargement of calyxes and longitudinal section

Heliolites elegans Hall (Fig. 40) (1852. *Pal. N. Y.* 2:130, pl. 36)

Distinguishing characters. Hemispheric form of corallum, which increases in size by lateral rather than interstitial addition; from 16 to 18 larger calyxes to the inch; pseudosepta reaching halfway to the center; microcorallites generally appearing solid; macrocorallites often standing out in relief in weathered specimens and having a stellate appearance.

Found in the lower part of the Lockport limestone at Lockport (Hall). May occur also at Niagara.

Heliolites spiniporus Hall (Fig. 41) (1852. *Pal. N. Y.* 2:131, pl. 34)

Distinguishing characters. Turbinate, pyriform, hemispheric or spheroidal form of corallum; divergent corallites, increasing in number by interstitial addition; circular macrocorallites with 12 pseudosepta, which extend only part way to the center; irregular or interrupted tabulae which often appear spiniform in section; microcorallites in one or more series, angular and tabulate.

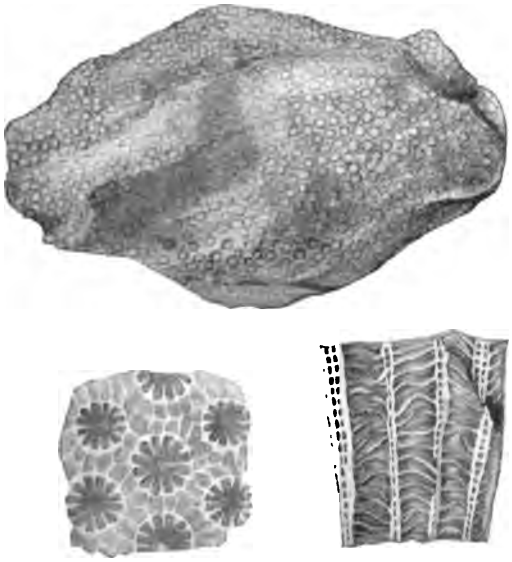


Fig. 41 Heliolites spiniporus with longitudinal and transverse sections enlarged

Found in the lower part of the Lockport limestone at Lockport (Hall). Probably also at Niagara.

Heliolites pyriformis Guettard (Fig. 42) (Hall. 1852. *Pal. N. Y.* 2:133, pl. 36A)

Distinguishing characters. Macrocorallites larger than preceding, and generally more widely separated; mostly several series of microcorallites, though they may sometimes be absent when macrocorallites are in contact; short pseudosepta.

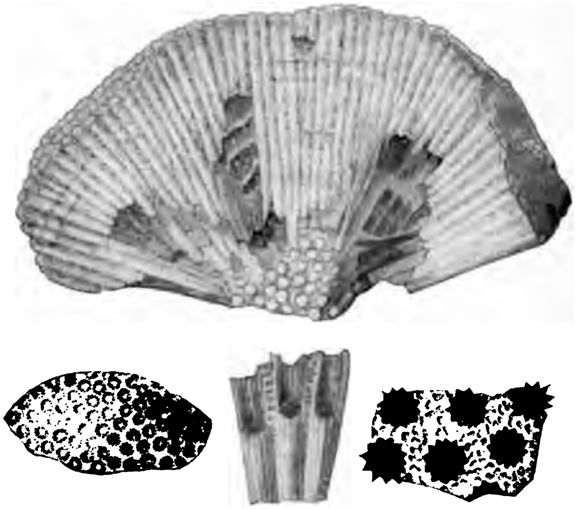


Fig. 42 Heliolites pyriformis

Found commonly in the lower Lockport limestone at Lockport (Hall). Probably also at Niagara.

Genus CLADOPORA Hall

[Ety.: κλάδος, twig; πόρος, pore]

(1852. *Pal. N. Y.* 2:137)

Corallum branching or reticulate; branches cylindric or slightly compressed with terete terminations. Corallites small, radiating equally on all sides from the axis, and opening on the surface in rounded or subangular expanded calyxes, which are generally contiguous, and apparently destitute of septa.

Cladopora seriata Hall (Fig. 43) (1852. *Pal. N. Y.* 2:137, pl. 38)

Distinguishing characters. Nearly parallel, rather closely crowded branches, forming a glomerate mass, the branches sometimes bifurcating; closely arranged corallites, gradually enlarging toward the surface of the branches. Calyxes in alternating series each margined on the lower side by a projecting circular lip.

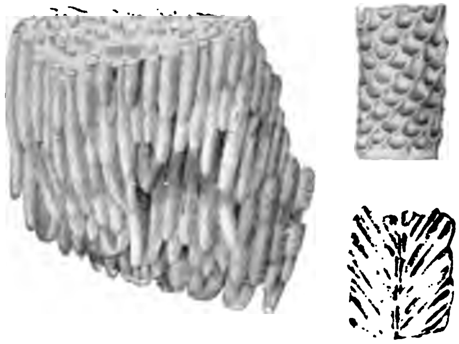


Fig. 43 Cladopora seriata with enlargement of a single branch showing the calyxes, and a section of same showing position of corallites

Found in the lower part of the Lockport limestone at Lockport (Hall), and in the Bryozoan bed of the Rochester shale at Niagara.

Cladopora multipora Hall (Fig. 44) (1852. *Pal. N. Y.* 2:140, pl. 39)

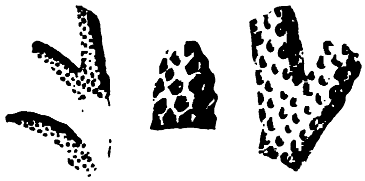


Fig. 44 Cladopora multipora, with enlargements

Distinguishing characters. Ramose or irregularly reticulate form, with the branches often extending beyond the last point of junction and ending in terete extremities; numerous closely arranged corallites, which are slightly oblique to the axis; calyxes subangular or circular, from 48 to 60 in the space of an inch.

Found in the lower part of the Lockport limestone at Lockport (Hall). Probably occurs also at Niagara.

Genus STRIATOPORA Hall

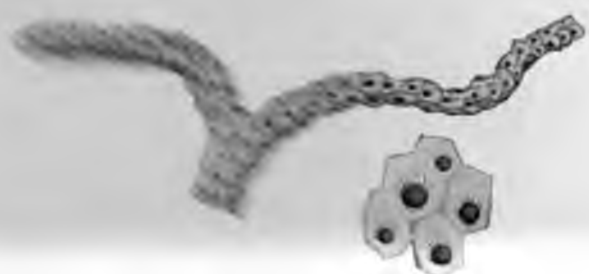
[Ety.: *striatus*, striated; *porus*, pore]

(1852. *Pal. N. Y.* 2:156)

Corallum dendroid, forming simple dividing, cylindric stems. Corallites essentially polygonal, diverging from an imaginary central axis, their walls greatly thickened by a secondary deposit of calcareous material or sclerenchyma, which increases in amount toward the calyxes. Calyxes in the form of circular apertures surrounded by a cup-shaped, thickened margin, the floor of which is striated by rudimentary septal ridges. Septal spines in vertical rows occasionally present. Tabulae few, widely separated, but extending completely across. Mural pores comparatively numerous, circular, and irregularly distributed.

Striatopora flexuosa Hall (Fig. 45) (1852. *Pal. N. Y.* 2:156, pl. 40B)

Distinguishing characters. Bifurcating or irregularly ramose stems with tersely terminating branches; calyxes circular, surrounded by large depressed cells, polygonal in outline and bounded by angular ridges; calycinal orifice in lower part of polygonal cell, vertically striate, the striae continuing upward in the surrounding cell.



[illegible] flexuosa with an enlargement of several calyxes

[illegible] commonly in the Bryozoan bed of the Rochester [illegible] generally well weathered out. Also in the same [illegible] (Hall).

Class CYSTOIDEA von Buch

[illegible] entirely extinct marine invertebrates which [illegible] during Paleozoic time. Most of them lived during [illegible] Silurian era but Cambric and Carbonic forms [illegible] were mostly stemmed organisms with a [illegible] like the crinoids, but a few of them were [illegible] which varies in form, is composed of poly- [illegible] united by close *sutures*. The plates vary [illegible] from 13 to several hundred, and only [illegible] regular arrangement. A radial arrange- [illegible] that of the Crinoidea occurs rarely, and the side plates pass insensibly into the plates of the ventral (upper) side. In the center of the dorsal side, however, a regular series of *basal plates* exists, which rest on the stem or column.

The mouth is indicated by a central or subcentral aperture on the upper (ventral) surface, and is sometimes covered by small plates. From it radiate from two to five simple or branching ambulacral grooves, which are also frequently roofed over by plates. The *anal opening* is situated eccentrically and frequently closed by a valvular pyramid.

The calyx plates in most cystoids are perforated by pores or fissures. These are often arranged to form lozenge-shaped or rhombic figures, the *pore rhombs*, which are disposed one half on each of two adjoining plates, while the line of suture between the plates forms either the longer or the shorter diagonal of the rhomb. The pores of opposite sides of the rhomb are united by perfectly closed, straight ducts, which pass horizontally across the line of suture, and produce a transversely striated appearance (Caryocrinus, fig. 46). These striate rhombs are generally visible only in weathered specimens. They may be present on all plates or only on a few. In Callocystites and other related genera, the *pore rhombs* are reduced to *pectinated rhombs*, which are few in number, and each separated into two distinct parts, lying on contiguous plates (fig. 47). These structures have probably a respiratory function.

The *arms* are feebly developed in the cystoids and often but few in number. They are simple, consisting of a single (uniserial) or a double (biserial) row of plates, and possess a ventral groove, protected by covering plates.

Genus CARYOCRINUS Say

[Ety.: *κάρυον*, a nut; *κρίνον*, lily]

(1825. *Acad. nat. sci. Phil. Jour.* 4:289)

Calyx composed of a moderate number of plates arranged in a hexamerous manner, and with the base composed of two cycles of plates (dicyclic). Lowest (*infrabasals*) four, unequal; followed by a second row of six basals, which alternate in position with those of the preceding and succeeding cycles. Third cycle of eight plates of which six are regarded as *radials*, the others as *interradials* (Carpenter). Ventral surface formed of six or more small pieces. All plates of the calyx furnished with pore-rhombs; the summit plates without perforations. Mouth and ambulacral grooves below the ventral plates or *tegmen*. Anal opening protected by a valvular pyramid, and situated on the outer margin of the ventral surface. Arms, 6 to 13 in number, situated on the ventral margin, and relatively feeble. Stem long, composed of cylindric segments.

Caryocrinus ornatus Say (Fig. 46) (Hall. 1852. *Pal. N. Y.* 2:216, pl. 49 and 49A)

Distinguishing characters. Stem of larger and smaller joints alternating near the calyx; edges of joints thin and sharp, sometimes slightly crenulated or denticulated; articulating surface radiately striate halfway to the center; canal round; calyx ovoid to subglobose, the greatest diameter usually below the middle; summit slightly convex with arms sometimes several inches long; upper margins of radial and interradial plates indented for the arm plates. Mural pores represented on the exterior of the plates by single or double rows of tubercles radiating from the centers of the plates to their angles; between these are numerous rows of smaller tubercles parallel to the sides of the plates.

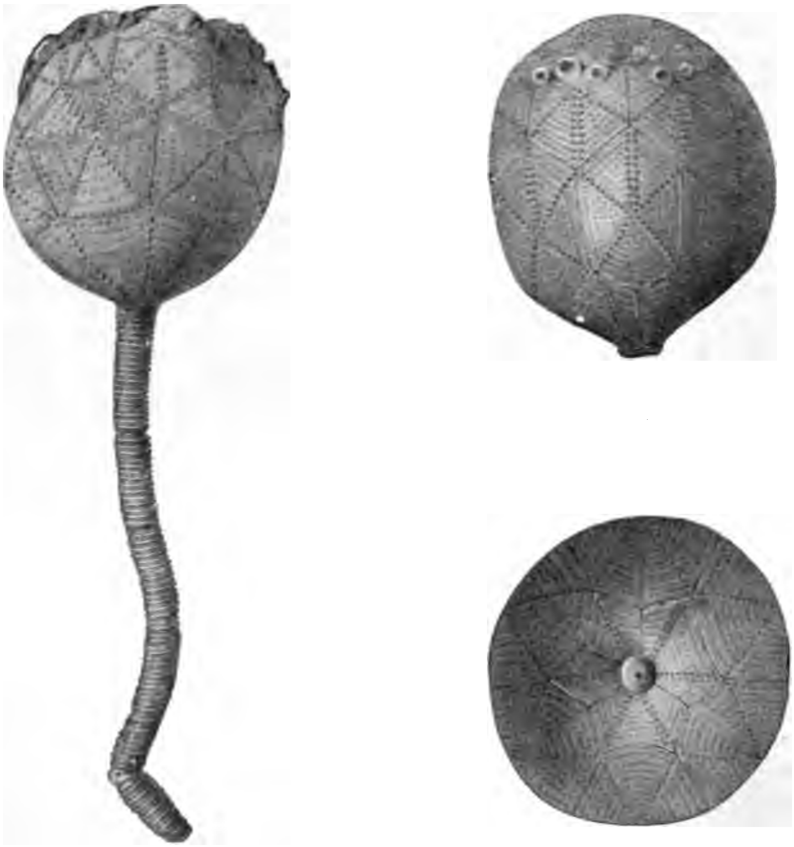


Fig. 46 Caryocrinus ornatus

Found in the Rochester shale at Niagara, Lockport and other places. Often very abundant. At Niagara it has been found as low as 4 feet above the Clinton limestone, and from that upward as far as the Bryozoa beds, in which it occurs in moderate abundance. It has not been found above these beds. It occurs chiefly in the calcareous layers of the shale, from which it weathers out, the nut-like calyxes rolling to the bottom of the section where they can be picked up by the side of the railroad track.[1]

Genus CALLOCYSTITES Hall

[Ety.: κάλλος, beauty; κύστις, bladder]

(1852. *Pal. N. Y.* 2:238)

Calyx composed of large plates arranged in three or four cycles and having four pectinated rhombs, the component halves of which stand on contiguous plates and are separated by an interval. Mouth slit-like, and forming the center of radiation for two to five pinnulated arms, which sometimes bifurcate, and are protected by covering pieces, and either repose on the calyx or are sunk below the surface in grooves. Stem well developed tapering down to a point.

Callocystites jewetti Hall (Fig. 47) (1852. *Pal. N. Y.* 2:239, pl. 50)

Distinguishing characters. Oblong ovoid, nearly symmetric form; base of four plates, one bearing part of pectinated rhomb; eight plates in second cycle; anal aperture between second and third cycle, excavated in two plates of the former and one of the latter; surface of plates ornamented by polygonal depressions, having a more or less defined border and granulose surface.

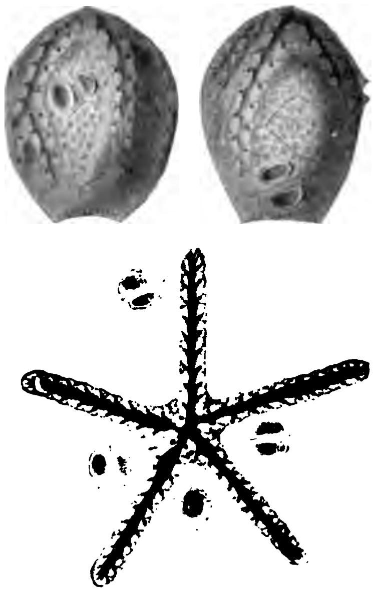


Fig. 47 Callocystites jewetti with the armgrooves spread out

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[1] Specimens of this "crinoid" may be purchased from John Garlow, the watchman on the middle section of the New York Central railroad cut in the gorge, at a moderate price.

Found in the Rochester shale at Lockport (Hall). Isolated fragments of plates have been obtained from the weathered lower Rochester shale in the Niagara gorge.

Class CRINOIDEA Miller

The crinoids, or sea lilies, are marine invertebrates, represented in the modern seas by a number of genera and species which range from shallow water to a maximum depth of about 3000 fathoms. They are gregarious in habit, and usually of very local distribution. A typical crinoid consists of a dorsal cup or *calyx*, placed on a *stalk or stem*, by means of which it is attached, and bears a fringe of *arms*, variously divided and furnished with jointed appendages, or *pinnules*. The calyx is composed of a number of plates, which have a definite arrangement, in horizontally disposed series (fig. 50). The lowest of these are the *basals*, though in many forms an additional series, the *infrabasals*, may underlie and alternate with the basals. Next above the basals, and alternating with them in position, are the *radials*, five in number, so called because they are in line with the rays or arms. Referring the position of the inferior plates to that of the radials, we find that the basals are always situated *interradially*, while the infrabasal are situated *radially*. Above the radials lie the *brachials*. These vary greatly in number and kind, sometimes articulating directly with the radials, in which case all the brachials are free, and sometimes having their lower series fixed and immovable, thus forming a part of the calyx. The brachials lying directly on the radials are the *costals;* of these there may be one or more series, when they are distinguished from below as *primary* (cost.^{1}), *secondary* (cost.^{2}), etc. The uppermost costal of each ray is commonly axillary, i. e. pentagonal in outline, with two upper joint edges inclined from each other. On these rest the *distichals*, of which there are 10 in each series. Secondary distichals (dist.^{2}) may rest on the primary ones (dist.^{1}), and may in turn support the *palmars*, of which there would be 20 in a normal series. Above these, on farther division, are the *post-palmars*, which are often very numerous. Two types of arms can be distinguished, those composed throughout of one series of plates (uniserial), and those made up of a double series (biserial), the plates of the latter usually interlocking to a greater or less extent. The latter are the more specialized, always beginning uniserially.

Between the radials are often found additional plates, the *interradials*, which may vary in number.

Between the distichals of one ray may occur the *interdistichals*, which are situated *radially*. Between the distichals of adjacent rays may occur the *interbrachials*, and these will be situated *interradially*.

An anal interradius is present in unsymmetric forms. The *tegmen* forms the cover, or ventral part of the calyx, and is composed of plates either closely ankylosed, or held together by a leathery membrane. In the Paleozoic Camerata the plates of the ventral disk fit closely and they are considerably thickened, forming a very rigid, more or less convex vault, from which may rise the plated anal proboscis.

The mouth of Paleozoic camerate crinoids lies beneath the tegmen, the only external opening being that of the anus. From the mouth, radiating grooves or canals commonly pass outward to the arms, in which they are continued. These are the ambulacral grooves, along which the food, caught on the arms, is conveyed to the central mouth. These grooves may be open or covered by plates. Within the cavity of the calyx are the viscera.

The stalk, or *stem*, is composed of a varying number of joints, which are circular, elliptic or angular in cross-section (fig. 52). The joint nearest to the calyx is the last formed except in the Flexibilia. Frequently a certain number of the joints bear rootlike extensions or *cirri*. The stem and cirri are pierced by an axial canal, round or pentagonal in cross-section. The stem was in most cases attached by a root. Some crinoids were without a stem, having been attached by the base directly or more rarely being free-swimming organisms.

Order LARVIFORMIA Wachsmuth & Springer

Genus STEPHANOCRINUS Conrad

[Ety. *στέφανος*, a crown; *κρίνον*, a lily]

(1842. *Acad. nat. sci. Phil. Jour.* 8:278)

Calyx cup-shaped, composed of three elongate basals, five radials, and five interradials. Radials deeply forked; the prongs formed by the margins of two continuous radials extending upward between the arms, and building, together with the interradials, a row of five pyramids, near the summit of one of which is situated the anal aperture. Radial incisions occupied by the ambulacral grooves, which are roofed over by two rows of covering pieces; those of the same row closely ankylosed. First costals semilunate, and resting within a horseshoe-like concavity near the outer end of the radial incisions. Tegmen constituted of five large triangular *oral plates*. Arms very short,[1] composed of about 10 pieces, all of which are axillary and give off side arms. The latter are biserial, non-pinnulate, and are made up of long, strongly cuneiform joints. Stem consisting of circular joints pierced by a circular axial canal.

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[1] Generally wanting in the weathered-out specimens.

Stephanocrinus angulatus Conrad (Fig. 48) (Hall. 1852. *Pal. N. Y.* 2:212, pl. 48, 83)

Distinguishing characters. Thick, equal stem joints, with crenulated, articulating margins, and minute round canal; form of calyx reverse pyramidal, gradually spreading from a triangular base upward; sutures scarcely visible; three basals, one pentagonal and two heptagonal; radials hexagonal with short excavated upper side; interradials broad below, contracting upward to form the coronal points; strong and angular carinae, six of which alternately converge upward and downward, while two others, somewhat stronger, extend from the bases of the heptagonal basals to the summit of the radials immediately succeeding; elevated tuberculated striae of the plates which extend transversely, vertically or obliquely on different parts of the calyx; surface sometimes merely tuberculated.

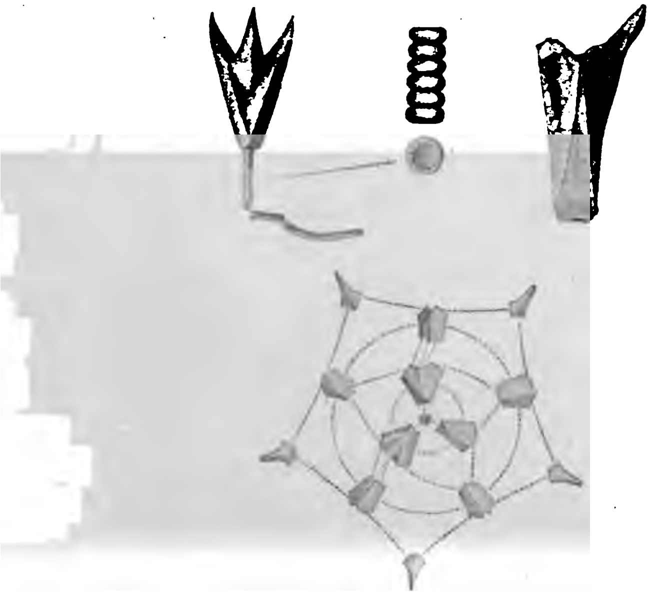

Fig 48 Stephanocrinus angulatus with an enlargement of the stem and an analysis of the calyx

Found in certain thin calcareous layers of the lower Rochester shale at Niagara, sometimes quite abundantly. Also in the same shale at Lockport (Hall). The crinoid is generally much lighter in color than the inclosing rock, and is easily distinguished. Associated with Eucalyptocrinus fragments and other crinoids, as well as other fossils.

Stephanocrinus gemmiformis Hall (Fig. 49) (1852. *Pal. N. Y.* 2:215, pl. 48)

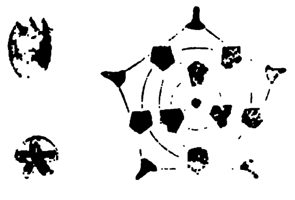

Fig. 49 Stephanocrinus gemmiformis with analysis of calyx

Distinguishing characters. Sharply triangular base; rapidly enlarging calyx, which is rotund in the middle and slightly contracted toward the summit. Upper margin of radials scarcely depressed or excavated; granular noncarinate surface of plates; slightly converging coronal processes.

Found in the Rochester shale at Lockport (Hall). Probably also at Niagara.

Order CAMERATA Wachsmuth & Springer

Genus THYSANOCRINUS Hall

[Ety.: θύσανος, fringe; κρίνον, lily]

(1852. *Pal. N. Y.* 2:188)

Calyx deep, with a dicyclic base. Infrabasals and basals five each, the former pentagonal, the latter generally hexagonal. Radials five, hexagonal, laterally in contact, except at the azygous side, where they are separated by an anal plate which is succeeded by three in-

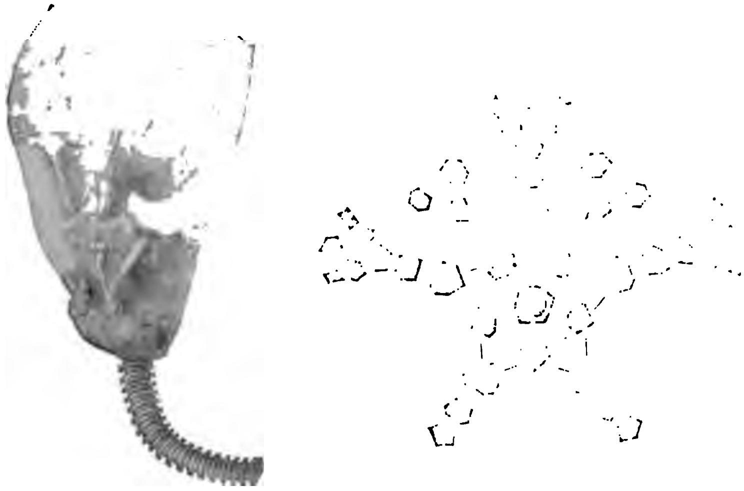

Fig. 50 Thysanocrinus liliiformis with analysis of calyx

terradial plates. Lower brachials forming a part of the calyx; cost.^{1} hexagonal, cost.^{2} pentagonal, axillary bearing the distichals. Interradials lying chiefly between the costals. Arms 10 to 20, biserial. Stem round.

Thysanocrinus liliiformis Hall (Fig. 50) (1852. *Pal. N. Y.* 2:188, pl. 42)

Distinguishing characters. Surface of plates ornamented by vertical or radiating, interrupted or crenulated, sharp, elevated striae; small infrabasals, large basals and still larger radials; three distichals in each of the 10 arms, the lowest large and hexagonal, the others cuneiform, followed by the biserial upper arm plates; stem joints round and alternatingly thin and thick, most irregular near the base of the calyx.

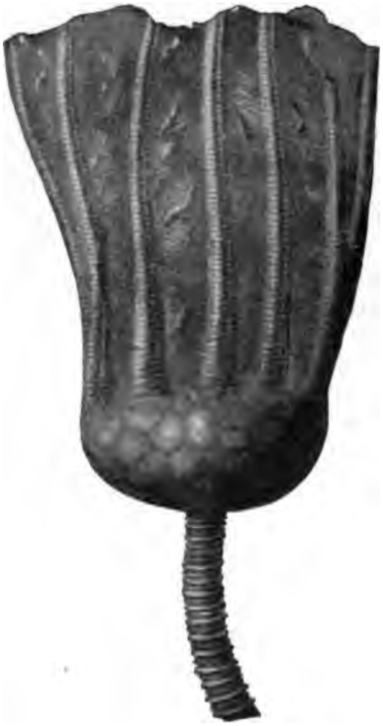

Fig. 51 Lyriocrinus dactylus

Found so far only in the Rochester shale at Lockport (Hall), but may also occur at Niagara.

Genus LYRIOCRINUS Hall

[Ety : λύριον, small lyre; κρίνον, lily]

(1852. *Pal. N. Y.* 2:197)

Calyx depressed, with a dicyclic base. Infrabasals five; basals five, pentagonal, truncated at the upper end. Radials separated all around by large interradials, which scarcely differ from the anal interradius. Anal aperture eccentric. Plates of the calyx smooth or finely granulose. Tegmen almost flat, composed of a large number of small plates. Arms 10, strong, simple and biserial. Stem round.

Lyriocrinus dactylus Hall (Fig. 51) (1852. *Pal. N. Y.* 2:197, pl. 44)

Distinguishing characters. Stem near the calyx of alternating larger and smaller joints, the larger projecting much beyond the smaller ones; calyx plates finely ornamented by granules, which become elongated near the margins of the plates; two simple distichals in each arm, abruptly followed by the biserial arm plates.

Found in the talus of the weathered Rochester shale above Lewiston, probably from the thin calcareous beds of the lower part of the shale. Also in the same shale at Lockport (Hall).

Glyptocrinus plumosus Hall (Fig. 52) (1852. *Pal. N. Y.* 2:180, pl. A41)

Under this name Hall has figured and described fragments of the stem and arms of a crinoid from the Clinton beds of western New York, which he states is extremely rare at Niagara, but often common farther east. The characteristics of these fragments are shown in the illustrations here reproduced.

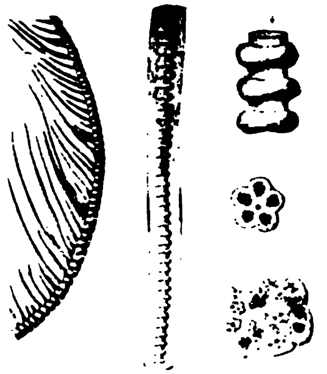

Fig. 52 Glyptocrinus plumosus the arm pinnules and stem with an enlargement of stem joints

Genus EUCALYPTOCRINUS Goldfuss

[Ety.: εὖ, well; καλύπτειν, cover; κρίνον, lily]

(1826. *Petrefacta Germaniae*, p. 212)

Calyx with a deep concavity at the lower end, of which the monocyclic base forms the bottom. Calycinal plates having throughout a pentameral arrangement, except the basals, which are only four in number. Radials in contact all around, costals 2 x 5, distichals 2 x 10, and above these the palmars in cycles of 20, and of small size. There are 1 x 5 large interradials, above which are two narrow and elongate interbrachials placed side by side. Between the distichals is in each ray one interdistichal, which has nearly the form and size of the two interbrachials combined. On the interbrachials and interdistichals and the tegmen rest 10 partitions, which extend upward and form compartments which contain two arms each. Arms biserial, composed of very narrow pieces. A proboscis surmounts the tegmen and projects above the arms. Stem round.

Eucalyptocrinus decorus (Phillips) (Fig. 53) (Hall. 1852. *Pal. N. Y.* 2:207, pl. 47)

Distinguishing characters. Stem consisting of alternating thicker and thinner joints, the former wider than the latter, with rounded edges; two or three thin joints between thick ones; articulating surfaces of joints deeply striated radially from margin nearly to the canal; canal pentapetalous; calyx subcylindric or ovoid, gradually enlarging from base upward to commencement of arms, then diminishing; summit contracted; surface of plates generally smooth.

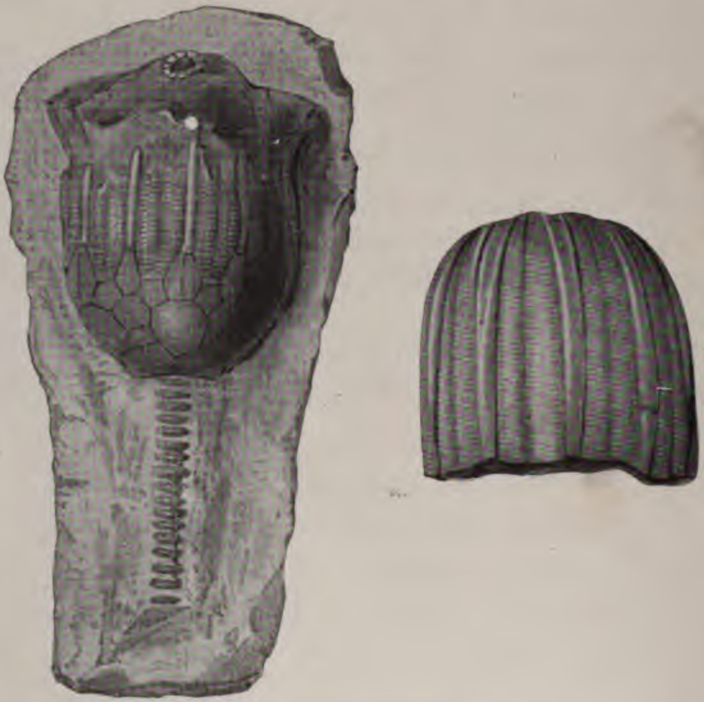

Fig. 53 Eucalyptocrinus decorus

Found in the lenses of limestone in the upper Clinton and in the calcareous beds of the lower Rochester shale, as well as the Bryozoan bed at Niagara. Often plentiful but generally in dissociated plates, of which the interbrachial partition plates are most readily recognized. The " roots " are occasionally found attached to corals, etc. Also represented in the middle and upper limestones at Niagara, but generally replaced. Also in the shale at Lockport and other localities (Hall).

Order FLEXIBILIA Zittel

Genus ICHTHYOCRINUS Conrad

[Ety.: ἰχθύς, fish; κρίνον, lily]

(1842. *Acad. nat. sci. Phil. Jour.* 8:279)

Calyx with all plates above the radials united by loose suture or by muscular articulation. Base dicyclic; infrabasals three, unequal, very small, rarely extending beyond the top stem joint with which they are fused. Basals five, small. Radials and lower brachials laterally in contact on all sides; no interradials or anals. Brachials united by more or less wavy sutures and their lower edges furnished with tooth-like projections which fit into depressions on the subjacent plates. Tegmen squamous, composed of five orals and numerous, very small, movable plates. Arms non-pinnulate, with a wide, shallow ventral groove. When the arms are folded, the crown appears like a perfectly solid body. Stem round, the upper joints extremely short, and generally wider than the others.

Ichthyocrinus laevis Conrad (Fig. 54) (Hall. 1852. *Pal. N. Y.* 2:195, pl. 43)

Distinguishing characters. Stem slender, round and smooth, gradually enlarging to the base of the calyx and composed of alternate thick and thin joints; radials five, succeeded by two to four costals in each radius; 10 columns of distichals, from six to nine plates in each, an unequal number in the two columns of each radius; 20 columns of palmars, and 40 of post-palmars, the number of plates varying in the columns of the same individual; plates with lower margins obtusely triangular and upper margins with a corresponding reentrant angle; axillary plates angular above and below.

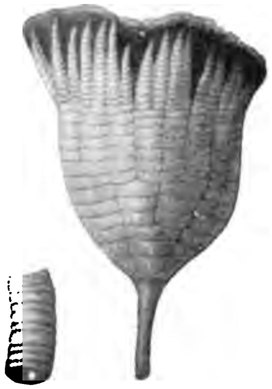

Fig. 54 Ichthyocrinus laevis with stem enlarged

Found in certain calcareous layers near the middle of the lower Rochester shales at Niagara. Also in the same shales at Lockport (Hall).

Genus LECANOCRINUS Hall

[Ety.: λεκάνη, basin; κρίνον, lily]

(1852. *Pal. N. Y.* 2:199)

This genus differs from Ichthyocrinus only in having a rhomboidal anal plate separating the two posterior radials, and followed by a somewhat larger anal interradial.

Lecanocrinus macropetalus Hall (Fig. 55) (1852. *Pal. N. Y.* 2:199, pl. 45)

Distinguishing characters. Subglobose calyx; three large infrabasals, the two larger truncated on top; larger basals, two pentagonal, one hexagonal and two heptagonal; subquadrangular anal plate following on heptagonal basals and succeeded by large interradial plate; large radials, two pentagonal and three with a short sixth side; costals 2 x 5, short, succeeded by distichals and palmars similar to Ichthyocrinus laevis; slender stem; smooth, thick joints alternating at irregular intervals with thin ones, and having slightly rounded edges and a round canal.

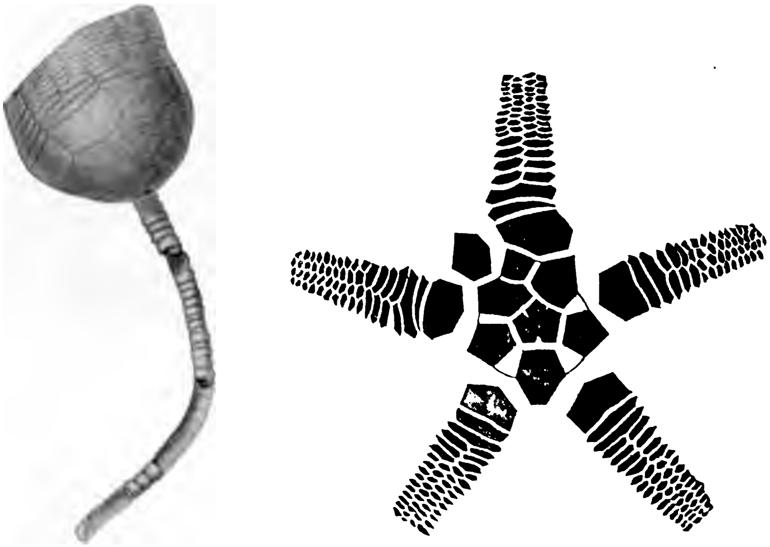

Fig. 55 Lecanocrinus macropetalus with analysis of calyx

Found in the Rochester shale at Lockport (Hall). May also occur at Niagara.

Class ANNELIDA Macleay

The annelids, or typical worms, are soft-bodied, marine, freshwater or terrestrial animals, whose remains can seldom be preserved in a fossil state. It is only the tube-building order (Tubicola) that leaves any satisfactory remains. In these the tube is either a calcareous secretion of the animal or is composed of agglutinated sand and other foreign particles, being, in each case, wholly external. Worm burrows are often preserved by sand or mud infiltration, a cast of the burrow appearing in the strata.

Genus CORNULITES Schlotheim

[Ety.: *cornu*, horn; λίθος, stone]

(1820. Schlotheim. *Petrefactenkunde*, p. 328)

Tube gently tapering, flexuous, the small end usually bent. The tube is either wholly or in part adherent to other objects. Walls thick, cellular, composed of imbricating rings. Surface ornamented by annulations and longitudinal striae. Interior presenting a succession of annular constrictions, giving a scalariform character to the cast.

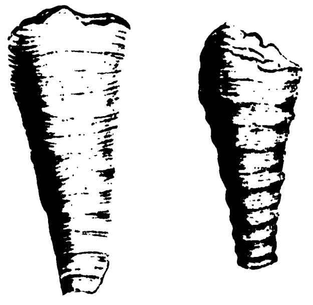

Fig. 56 Cornulites bellistriatus

Cornulites bellistriatus Hall (Fig. 56) (1852. *Pal. N. Y.* 2:353, pl. 85, fig. 13-17, and v. 7, supplement, p. 20, pl. 116A, fig. 12, 13)

Distinguishing characters. Wall thick; annulations slightly marked at base, less strongly and irregularly marked in upper portion; fine longitudinal striae well marked throughout.

Found in the talus of Rochester shale, along the Rome, Watertown and Ogdensburg railroad above Lewiston hights.

Class BRYOZOA Ehrenberg

The Bryozoa, or Polyzoa, are marine or fresh-water invertebrates, almost always occurring in colonies or zoaria which increase by gemmation. Each *zooid* of the colony is inclosed in a membranaceous, or calcareous, double-walled sac, the *zooecium*, into which it can withdraw. The animal possesses a mouth, an alimentary canal and an anal opening, and, in addition to these, a fringe of respiratory tentacles—the *lophophore.* The colony is commonly attached to foreign bodies, which it either incrusts or from which it arises as an independent frond.

In the Paleozoic genera the cell apertures are often surrounded by elevated rims, or *peristomes.* In many forms a portion of the posterior wall of the tube is more or less thickened, and curved to a shorter radius, often projecting above the plane of the aperture. This forms the *lunaria,* and their ends may project into the tubes as *pseudosepta.* In the interapertural space may occur angular or irregular cells, the *mesopores,* while on many portions of the surface, tubular spines (*acanthopores*), or nodes (rounded, knob-like elevations), may occur. At intervals, in many genera, rounded elevations, or *monticules,* are found, which may, or may not, be destitute of cells. *Maculae* or irregular blotches, destitute of cells, also occur in many forms. Some species bear a superficial resemblance to certain corals, particularly the monticuliporoids.

Genus DIPLOCLEMA Ulrich

[Ety.: διπλόος, double; κλῆμα, twig]

(1890. *Geol. sur. Illinois,* 8:368)

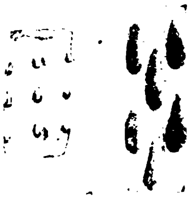

Fig. 57 Diploclema sparsa enlargements of fresh and worn branches

Zoarium dendroid, branches slightly compressed, spreading in the same plane; zooecia tubular, diverging from a wavy mesial mesotheca; apertures circular; prominent.[1]

Diploclema sparsa (Hall) (Fig. 57). Trematopora sparsa Hall (1852. *Pal. N. Y.* 2:155, pl. 40A, fig. 12a-d)

Distinguishing characters. Slender, cylindric bifurcating stems; distant cells, opening obliquely upward; elongated nariform calicles.

Found abundantly in the Rochester shale at Lockport (Hall) probably also at Niagara.

Genus CERAMOPORA Hall

[Ety.: κέραμος, a tile; πόρος, pore]

(1852. *Pal. N. Y.* 2:168)

Zoarium disk-like, free or attached by the center of the base; under surface with one or more layers of small, irregular cells; zooecia tubular, radiating on the upper surface from a depressed center; apertures oblique, imbricating, provided with a lunarium; mesopores short, irregular, decreasing in number from center to margin; large maculae or clusters of mesopores or of zooecia at regular intervals.

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[1] The generic descriptions of the Bryozoa are adapted or transcribed from Nickles & Bassler: Synopsis of American fossil Bryozoa. U. S. geol. sur. Bul. 173. I have also followed these authors in the synonomy of the species.

Ceramopora imbricata Hall (Fig. 58) (1852. *Pal. N. Y.* 2:169, pl. 40E, fig. 1a-i)

Distinguishing characters. Depressed hemispheric form, flattened or convex on the lower side; composed of cylindric or subcylindric tubes slightly diverging from the center, rectangular to plane of upper surface; arched or triangular aperture, opening on all sides toward the outer margin, arranged in alternating and imbricating series.

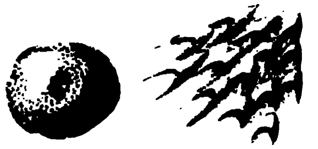


Fig. 58 Ceramopora imbricata with enlargement of surface

Found in the Rochester shale at Lockport (Hall) and probably also at Niagara.

Ceramopora incrustans Hall (Fig. 59) (1852. *Pal. N. Y.* 2:169, pl. 40E, fig. 2a-d)

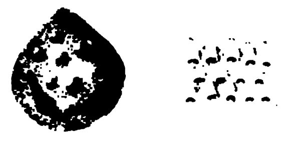


Fig. 59 Ceramopora incrustans with enlargement of surface

Distinguishing characters. Incrusting habit; cells increasing unequally from a center or point of growth, short, minute, opening obliquely outward and arranged in quincunx order.

Found in the Rochester shale at Lockport (Hall); may also occur at Niagara.

Genus CHILOTRYPA Ulrich

[Ety.: *χεῖλος*, lip; *τρῦπα*, perforation]

(1884. *Cin. soc. nat. hist. Jour.* 7:49)

Zoarium small, branching, with a narrow, irregularly contracting and expanding tube; zooecial tubes cylindric or somewhat compressed, thin walled, with or without diaphragms; walls minutely porous; apertures elliptic, oblique, the lower margin thickened and elevated; at irregular intervals maculae or monticules, composed of clusters of vesicles and of zooecia slightly larger than the average occur; interzooecial spaces occupied by vesicular tissue, which is commonly filled by a dense calcareous deposit near the surface.

Chilotrypa ostiolata (Hall) (Fig. 60). Trematopora ostiolata Hall (1852. *Pal. N. Y.* 2:152, pl. 40A, fig. 5a-n)

Distinguishing characters. Irregularly branching cylindric stems gradually tapering toward the extremities, which are obtuse; apertures about their diameter apart, arranged in spirally ascending lines or irregularly; strong peristomes; interapertural spaces smooth; stems solid or incrusting crinoids.

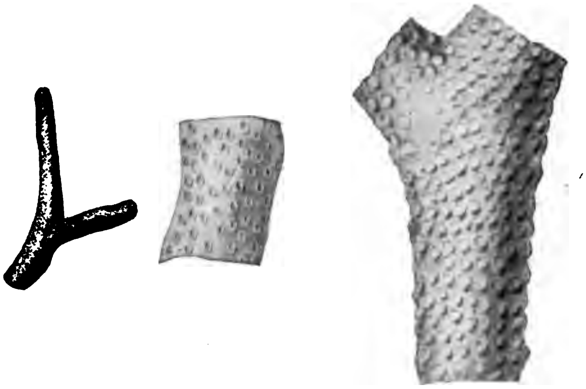


Fig. 60 Chilotrypa ostiolata; branch natural size and two enlargements

Found abundantly in the Bryozoa beds of the Rochester shale and in some of the calcareous layers below it in the Niagara sections. Also at Lockport, etc. (Hall).

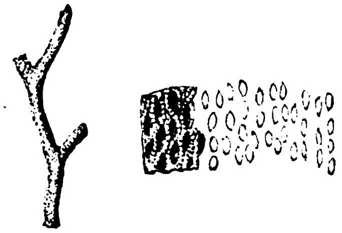


Fig 61 Batostomella granulifera with enlargement of part of surface

Genus BATOSTOMELLA Ulrich

[Ety.: βάτος, bramble; στόμα, mouth]

(1882. *Cin. soc. nat. hist. Jour.* 5:154)

Zoarium ramose, branches slender; zooecia with thick walls in the mature region and with few diaphragms in the peripheral region, often centrally perforated; apertures small, circular or oval; interspaces rounded or canaliculate, spinulose; acanthopores small and usually very numerous; mesopores small, with subcircular openings.

Batostomella granulifera (Hall) (Fig. 61). Trematopora granulifera Hall (1852. *Pal. N. Y.* 2:154, pl. 40A, fig. 9a-e)

Distinguishing characters. Slender branches; oval to elongate apertures, margined by wavy, raised, granulose lines, which are double between the cells.

Found rarely in the lower Rochester shale, associated with Ichthyocrinus and other rare fossils. Niagara sections. Also in the same shale at Lockport (Hall).

Genus LIOCLEMA Ulrich

[Ety.: λεῖος, smooth; κλῆμα, twig]

(1882. *Cin. soc. nat. hist. Jour.* 5:141, 154)

Zoarium ramose, lamellar, subglobose or incrusting; surface frequently exhibiting distinct monticules or maculae; zooecia with subcircular or irregularly petaloid apertures, separated by abundant angular mesopores, which in some species are open at the surface, in others closed; diaphragms few in the zooecia, abundant, sometimes crowded in the mesopores; acanthopores numerous and strong in the typical species, small and inconspicuous in others.

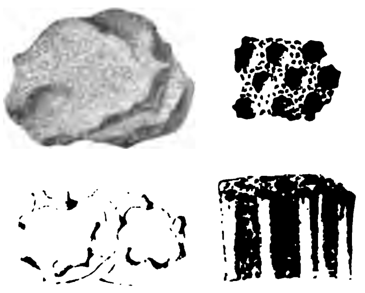


Fig. 62 Lioclema florida with side and summit views enlarged, and two calyxes much enlarged

Lioclema florida (Hall) (Fig. 62). Callopora florida Hall (1852. *Pal. N. Y.* 2:146, pl. 40, fig. 2a-f)

Distinguishing characters. Explanate or incrusting habit; tubular cells; floriform apertures the margins of which appear as if formed of segments of six or seven smaller curves; each angle of aperture furnished with spine (acanthopore); mesopores angular in perfect specimens.

Found in the Bryozoa beds of the Rochester shales at Niagara, rare. Also at Lockport (Hall).

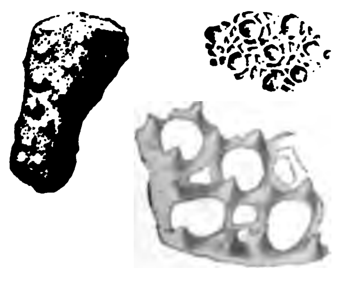


Fig. 63 Lioclema aspera with enlargements of surface

Lioclema aspera (Hall) (Fig. 63). Callopora aspera Hall (1852. *Pal. N. Y.* 2:147, pl. 40, fig. 4a-i)

Distinguishing characters. Stems solid or hollow cylinders, often also incrusting other bodies in broad, explanate or foliate expansions; clavate or thickened extremities of stems; circular or slightly oval apertures; finely reticulated interspaces; margins of apertures surrounded by minute points (acanthopores) which give the entire surface an asperato-granular appearance.

Found in the Rochester shale at Lockport (Hall), and probably also at Niagara.

Genus BYTHOPORA Miller & Dyer

[Ety.: βυθός, depth; πόρος, pore]

(1878. *Contrib. to paleontology* no. 2, p. 6)

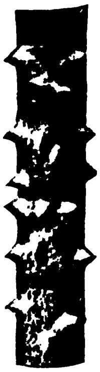


Fig. 64. Bythopora spinulosa enlarged

Zoarium usually with slender branches, sometimes of considerable size; diaphragms obsolete; apertures oblique, narrowing above; interspaces canaliculate; mesopores few; acanthopores strong, rarely more than one to each zoarium, sometimes wanting.

Bythopora spinulosa (Hall) (Fig. 64). *Trematopora spinulosa* Hall (*Pal. N. Y.* 2:155, pl. 40A)

Distinguishing characters. Oval apertures; cylindrical branches; strong spines (acanthopores) arranged at nearly regular intervals.

Found in the Rochester shale at Lockport. (Hall) Probably occurs also at Niagara.

Genus TREMATOPORA Hall

[Ety.: τρῆμα, foramen; πόρος, pore]

(1852. *Pal. N. Y.* 2:149)

Zoarium ramose; surface smooth or with monticules; zooecia thin-walled, the contact lines of walls of adjoining zooecia distinct; diaphragms few, in the proximal ends of the zooecia; apertures circular or oval, with a more or less well marked peristome; interspaces solid; mesopores irregularly angular, often obscurely moniliform, with diaphragms at the constricted parts; acanthopores of medium or small size usually present.

Trematopora tuberculosa Hall (Fig. 65) (1852. *Pal. N. Y.* 2:149, pl. 40A, fig. 1a-g)

Distinguishing characters. Irregularly ramose and stout branches; tuberculous monticules; tubular cells with oval apertures and thin elevated calicle or margin which is spinulose (bearing acanthopores); interapertural spaces solid, but septate below.

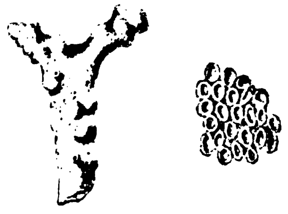


Fig. 65 Trematopora tuberculosa with enlargement of surface

Found abundantly in the Bryozoa beds of the Rochester shales, at Niagara, also at Lockport (Hall).

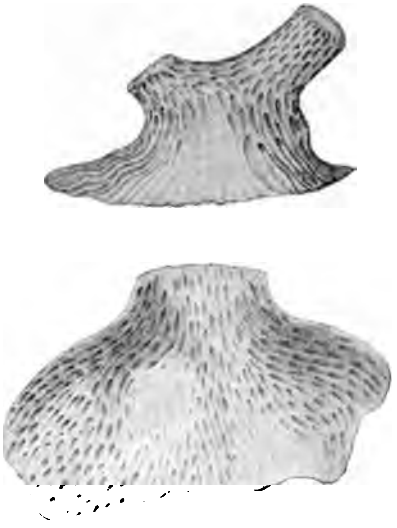


Fig. 66 Trematopora (?) striata much enlarged

Trematopora (?) striata Hall (Fig. 66) (1852. *Pal. N. Y.* 2:153, pl. 40A, fig. 7a-d and 8a-b)

Distinguishing characters. Expanded at the base; strongly striated; slender, cylindric, scarcely tapering branches; oblong oval apertures distant from each other about the width of the aperture; interapertural space with continuous groove.

Found in the Rochester shale at Lockport (Hall), probably also at Niagara.

Genus CALLOPORA Hall

(emend. Ulrich)

[Ety.: κάλλος, beauty; πόρος, pore]

(1852. *Pal. N. Y.* 2:144)

Zoarium usually ramose, the branches frequently anastomosing and forming bushy clumps; zooecia at first prismatic, four to eight sided, gradually becoming cylindric in most cases; at first with closely set diaphragms, becoming more distant, finally in the mature region usually closely set; apertures closed at times by perforated, often ornamental covers; mesopores more or less numerous, angular, crowded with diaphragms. No acanthopores.

Callopora elegantula Hall (Fig. 67) (1852. *Pal. N. Y.* 2:144, pl. 40, fig. 1a-m)

Distinguishing characters. Cespitose or fruticulose groups of small stems frequently branching; branches bifurcating or variously diverging from the stem; solid; extremities often hollow or cup-like indentations, also blunt; apertures circular, the opercula or covers

with a central perforation from which radiate a number of ridges, giving the cells often a radiately septate appearance; mesopores single, in groups or encircling the apertures.

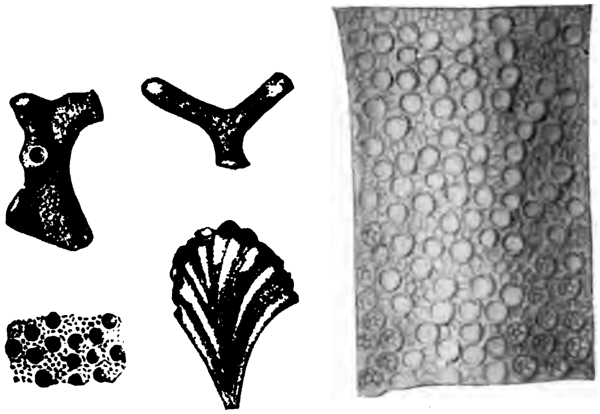


Fig. 67 Callopora elegantula with enlargements of surface, and individual tubes

Found abundantly in the Bryozoa beds of the Rochester shale at Niagara. Also common at Lockport (Hall).

Genus PHYLLOPORINA Ulrich

[Ety.: φύλλον, leaf; πόρος, pore]

(1890. *Geol. sur. Illinois,* 8:399, 639)

Zoarium branching, with branches irregularly anastomosing, with two to eight rows of apertures on one side, longitudinally striated on the other; zooecia more or less tubular, often with diaphragms, and generally separated by tabulated interstitial spaces, which are closed at the surface; acanthopores often present.

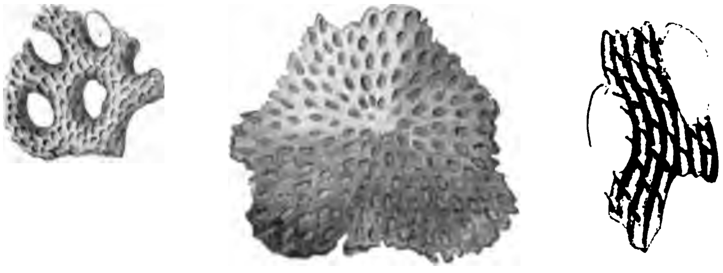


Fig. 68 Phylloporina asperato-striata with enlargement of celluliferous and non-celluliferous faces, the latter showing the asperate-striate character

Phylloporina asperato-striata (Hall) (Fig. 68). Retepora asperato-striata Hall (1852. *Pal. N. Y.* 2:161, pl. 40C, fig. 2a-h)

Distinguishing characters. Network of anastomosing branches, with oval interstices which are somewhat unequal; outer face roughly striate; inner face poriferous; three, four or more rows of oval or subangular cells arranged somewhat in oblique parallel lines or in quincunx order; apertures in perfect specimens probably with peristomes.

Found abundantly in the Bryozoa beds of the Rochester shale at Niagara. Generally adhering to the shale laminae by the celluliferous face. Also at Lockport (Hall).

Genus DRYMOTRYPA Ulrich

[Ety.: *δρῠμός*, coppice; *τρῦπα*, perforation]

(1890. *Geol. sur. Illinois.* 8:399)

Zoarium branching dichotomously at frequent intervals; zooecia in several ranges, tubular, opening on one side only and springing from a thin double plate, beneath which a number of vesicles are present; reverse side longitudinally striated; vestibules expanding from the orifices to the angular apertures.

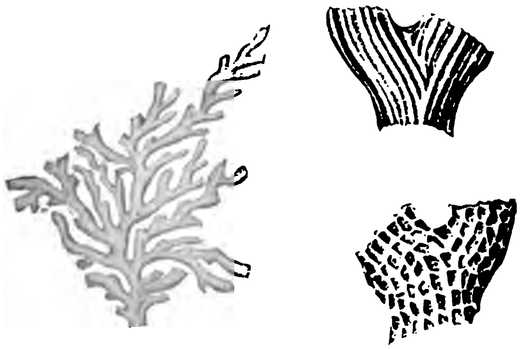


Fig. 69 Drymotrypa diffusa with celluliferous and non-celluliferous sides enlarged

Drymotrypa diffusa (Hall) (Fig. 69) Retepora diffusa Hall (1852. *Pal. N. Y.* 2:160, pl. 40C, fig. 1a-f)

Distinguishing characters. Shrubby form, several stems originating from a common base; stems frequently bifurcating and spreading laterally, forming a broad frond; stems and branches celluliferous on one side only, deeply striated longitudinally on the other; quadrangular or subrhomboidal apertures; branches often thickened or clavate, always obtuse.

Found in the upper part of the lower Rochester shale and the Bryozoa beds at Niagara. Rare. Also at Lockport (Hall).

Genus FENESTELLA Lonsdale

[Ety.: *fenestella*, a little window]

(1839. Murchison. *Silurian system*, p. 677)

Zoarium consisting of a calcareous branching frond, forming cup-shaped or funnel-shaped expansions. The branches fork, and are connected by transverse bars or dissepiments, thus inclosing spaces or fenestrules. The cell apertures occur only on the inner side of the branches. They are surrounded by rims or peristomes and are arranged in two parallel rows, while between them occurs a ridge (carina) or a row of nodes.

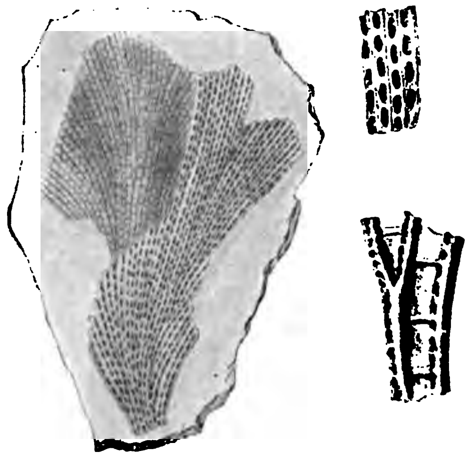


Fig. 70 Fenestella elegans with enlargements

Fenestella elegans Hall (Fig. 70) (1852. *Pal. N. Y.* 2:164, pl. 40D, fig. 1a-g)

Distinguishing characters. Carina subdued; apertures with their longer diameter oblique to the direction of the branches; branches slender, frequently bifurcating; thin and slender dissepiments scarcely enlarging at the junction with the branches; fenestrules on

non-celluliferous side oblong, quadrangular, rarely oval; branches finely striate.

Found in the Bryozoa bed of the Rochester shale at Niagara. Also in the same rock at Lockport and elsewhere (Hall).

Genus **SEMICOSCINIUM** Prout

[Ety.: *semi*, half (somewhat like); κόσκινον, sieve; Coscinium, a genus of Bryozoa]

(1859. *St Louis acad. sci. Trans.* 1:443)

Zoarium funnel-shaped, celluliferous on the outer side: dissepiments wide, very short, the branches appearing to anastomose on the non-poriferous face, where the fenestrules are subrhomboidal or rounded. Apertures in two rows, with a very high median keel, which is expanded at the summit.

Semicoscinium tenuiceps (Hall) (Fig. 71, 72). Fenestella tenuiceps Hall (1852. *Pal. N. Y.* 2:165, pl. 40D, fig. 2a-h) Fenestella prisca? Hall (1852. *Pal. N. Y.* 2:50, pl. 19, fig. 4a-m)

Distinguishing characters. Carina sharp and thin: transverse dissepiments not extending as high as the branches, sometimes scarcely visible; round large apertures opening laterally so as to be scarcely visible when looking down on the frond; non-celluliferous side with oval fenestrules, branches on non-celluliferous side striate, appearing granular when worn.

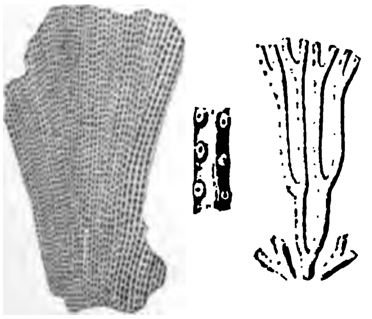


Fig. 71 Semicoscinium tenuiceps, Clinton. With enlargements

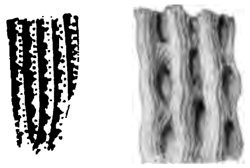


Fig. 72 Semicoscinium tenuiceps, Niagara. Enlargements of celluliferous and non-celluliferous faces

Found in the Bryozoa beds of the Rochester shales at Niagara; also at Lockport (Hall) (?). It also occurs in the Clinton beds at Lockport, and probably also at Niagara.

Genus POLYPORA McCoy

[Ety.: πολύς, many; πόρος, pore]

(1845. *Synopsis Carbon. foss. Ireland*, p. 206)

Zoarium as in Fenestella, but with from two to eight rows of zooecia on a branch, and without median keel, but sometimes with a row of strong nodes or tubercles.

Polypora incepta Hall (Fig. 73) (1852. *Pal. N. Y.* 2:167, pl. 40D, fig. 5a-f)

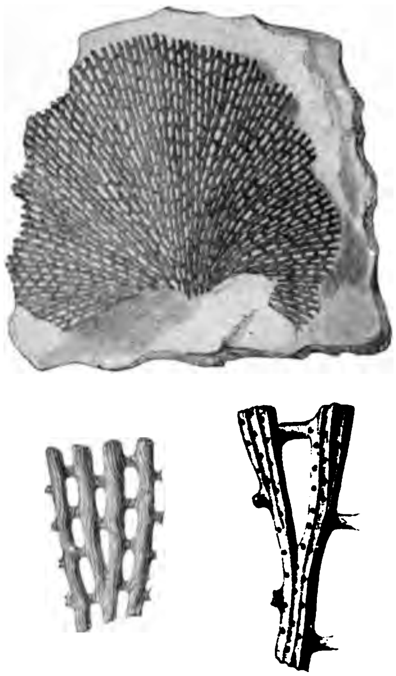


Fig. 73 Polypora incepta with non-celluliferous and celluliferous faces enlarged

Distinguishing characters. Funnel-shaped, but generally compressed form; branches dividing somewhat regularly, sometimes anastomosing; dissepiments at regular intervals, slender, scarcely thickened at their junction with branches; fenestrules oblong, quadrangular, rarely oval; non-celluliferous face longitudinally striate; three or four rows of cell apertures, oval and alternating; dissepiments thinner on celluliferous than on non-celluliferous face; sometimes expanding at the junction with the branches; non-celluliferous face indistinguishable from Fenestella.

Found abundantly in the Bryozoa beds of the Rochester shale at Niagara, and the talus of the cliff above Lewiston hights. Also in the shale at Lockport (Hall).

Genus HELOPORA Hall

[Ety.: ἧλος, nail; πόρος, pore]

(1852. *Pal. N. Y.* 2:44)

Zoarium bushy, dichotomously branching, the whole consisting of numerous slender, equal segments, united by terminal articulations; zooecia subtubular, more or less oblique, radially arranged about a central axis and opening on all sides of the segments.

Helopora fragilis Hall (Fig. 74) (1852. *Pal. N. Y.* 2:44, pl. 18, fig. 3a-f)

Distinguishing characters. Minute cylindric or clavate zoarium swollen at one end; oval or subangular pores, having a spiral direction around the stipe and arranged between longitudinal elevated lines.

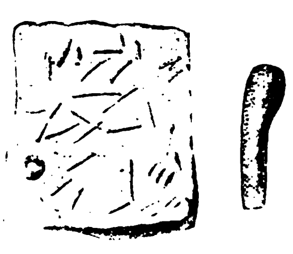


Fig. 74 Helopora fragilis natural size and enlarged

Found in the Clinton beds at Lockport etc. (Hall). Probably occurs also at Niagara. Also abundant in the thin calcareous upper Medina layers at Niagara (?).

Genus CLATHROPORA Hall

[Ety.: *clathri*, a lattice; *porus*, a pore]

Zoarium composed of anastomosing branches, forming a regular network with round or oval spaces or fenestrules, with a pointed, articulating base; the branches are made up of two layers grown together back to back, and with the zooecial tubes opening on both sides of the frond; apertures usually subquadrate, arranged longitudinally.

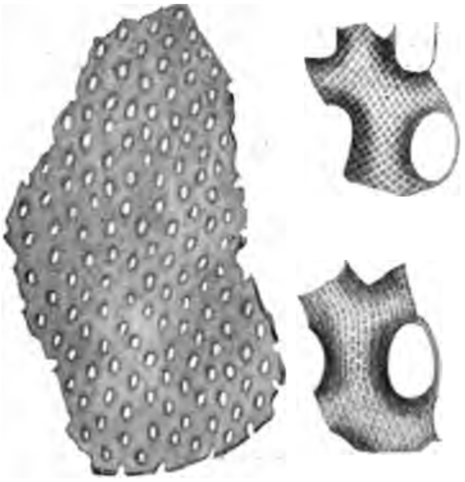


Fig. 75 Clathropora frondosa with portions of celluliferous face enlarged

Clathropora frondosa Hall (Fig. 75) (1852. *Pal. N. Y.* 2:160, pl. 40B, fig. 5a-e)

Distinguishing characters. Reticulate, expanded, flabellate or funnel-shaped frond, both surfaces regularly and equally celluliferous; apertures rhomboidal or oblong quadrangular, opening obliquely upward.

Found in the Rochester shale at Lockport (Hall) and probably also at Niagara.

Clathropora alcicornis Hall (Fig. 76) (1852. *Pal. N. Y.* 2:159, pl. 40B, fig. 4a-c)

Distinguishing characters. Cylindric branches, bifurcating and variously branched; entire surface celluliferous; apertures quadrangular, rhomboidal or oblong and variable in form at the division of the stem.

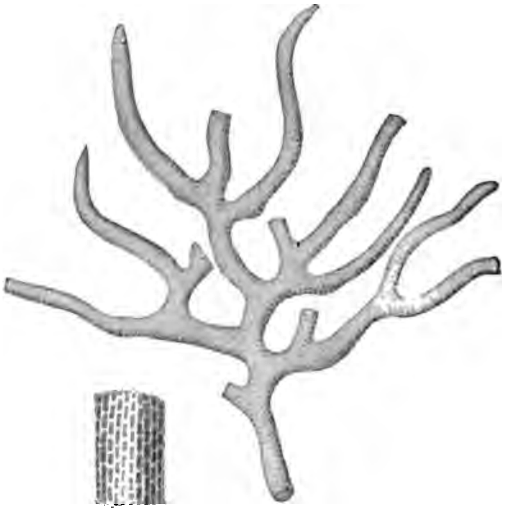


Fig. 76 Clathropora alcicornis with enlargement

Found in the lower Rochester shale up to and in the Bryozoa bed at Niagara. Rare. Also at Lockport (Hall).

Genus RHINOPORA Hall

[Ety.: ῥινός, hide; πόρος, pore]

(1852. *Pal. N. Y.* 2:48)

Zoarium forming large, undulating bifoliate expansions, celluliferous on both sides; surface usually smooth, rarely with solid monticules, and traversed by slender, rounded, bifurcating ridges, which appear as shallow grooves when the surface is worn; apertures nearly circular, occupying the summits of prominent papillae; mesopores present, but closed at the surface; large median tubuli in the middle layer or *mesotheca*.

Rhinopora tuberculosa Hall (Fig. 77) (1852. *Pal. N. Y.* 2:170, pl. 40E, fig. 4a-e)

Distinguishing characters. Lamellose or explanate palmate fronds; asperate and tuberculous surface; tubercles mostly destitute of cells at the summit; cells rising in pustules on the surface and opening by roundish oval or tripetalous apertures.

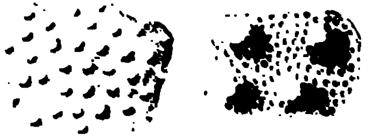


Fig. 77 Rhinopora tuberculosa with enlargement

Found in the Rochester shale at Lockport (Hall) and probably also at Niagara.

Genus DIAMESOPORA Hall

[Ety.: διά, through; μέσος, middle; πόρος, pore]

(1852. *Pal. N. Y.* 2:158)

Zoarium ramose, of hollow stems lined internally by an epitheca; zooecia simple, hexagonal, or rhomboidal, with an oval orifice in the anterior half, which, with growth, forms a tubular vestibule; aperture with peristomes equally elevated or highest posteriorly; intervestibular spaces compact or horizontally laminated.

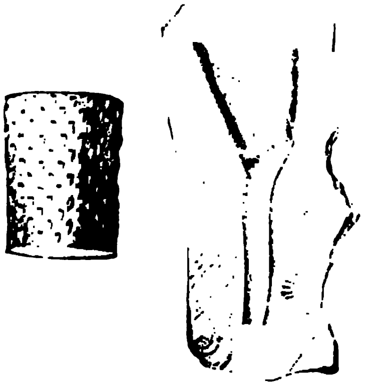


Fig. 78 Diamesopora dichotoma with enlargement

Diamesopora dichotoma Hall (Fig. 78) (1852. *Pal. N. Y.* 2:158, pl. 40B, fig. 3a-d)

Distinguishing characters. Cylindric, hollow, regularly bifurcating stems (a thin crust inclosing inorganic matter); interior of hollow branches transversely striate; cells opening upward in regular ascending or spiral lines; prominent nariform peristomes; stems usually flattened.

Found in the Bryozoa beds of the Rochester shales at Niagara, usually in a crushed condition. Also at Lockport (Hall).

with a central perforation from which radiate a number of ridges, giving the cells often a radiately septate appearance; mesopores single, in groups or encircling the apertures.

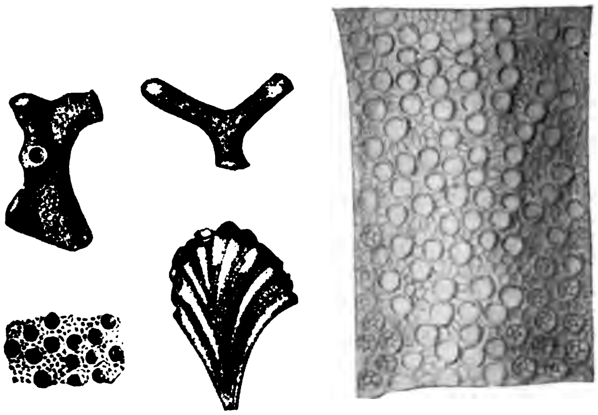


Fig. 67 Callopora elegantula with enlargements of surface, and individual tubes

Found abundantly in the Bryozoa beds of the Rochester shale at Niagara. Also common at Lockport (Hall).

Genus PHYLLOPORINA Ulrich

[Ety.: φύλλον, leaf; πόρος, pore]

(1890. *Geol. sur. Illinois*, 8:399, 639)

Zoarium branching, with branches irregularly anastomosing, with two to eight rows of apertures on one side, longitudinally striated on the other; zooecia more or less tubular, often with diaphragms, and generally separated by tabulated interstitial spaces, which are closed at the surface; acanthopores often present.

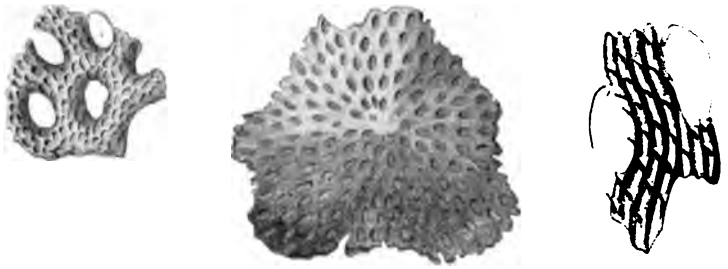


Fig. 68 Phylloporina asperato-striata with enlargement of celluliferous and non-celluliferous faces, the latter showing the asperate-striate character

Class BRACHIOPODA Cuvier

The Brachiopoda are marine animals, sparingly represented in modern seas, but most prolific in the Paleozoic and early Mesozoic waters.

The valves of the brachiopod shell are dorsal and ventral, and not right and left as in the lamellibranch Mollusca; they are unequal, and each is symmetric with reference to a median line (longitudinal axis) drawn through its apex. The larger valve may have its beak truncated or furnished with an opening or *foramen*, for the emission of the fleshy *pedicle*, by means of which the animal fixes itself to rocks, shells or other substances.

Certain genera, such as Crania, do not conform to this mode of fixation, but cement their shell directly to the foreign object, while others, e. g. Pholidops, appear to have led a free existence. In many of the discinoid genera, such as Orbiculoidea, the pedicle passed through an opening in the lower valve; while in Lingula it protruded between the two very nearly equal valves. In all cases the valve giving emission to the pedicle is spoken of as the *pedicle valve*.

The opposite valve in the more specialized genera bears on its interior two short processes, or *crura*, which arise from the hinge plate. To these may be attached a calcareous *brachidium*, which functions as a support for the delicate fleshy "arms". In a large number of forms this brachidium is absent, and the fleshy arms are directly supported by the crura, but their relation to the valve in question is similar to that obtaining in the brachidium-bearing forms. This valve is designated the *brachial* valve. In all the forms in which the valves are articulated with each other (Brachiopoda articulata) such articulation is produced by *teeth* arising from the pedicle valve and lodged in *sockets* in the brachial valve. The beak of the brachial valve is commonly furnished with a more or less pronounced *cardinal process*, which, at its

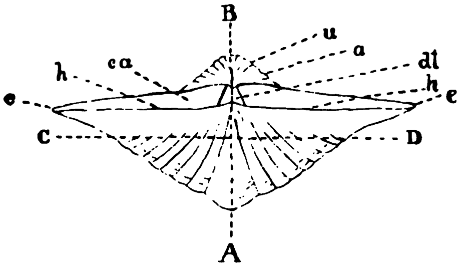


Fig. 80 Diagram of Spirifer. (AB) Longitudinal axis marking the hight; (CD) Transverse axis marking the width; (a) Anterior (front) end; (B) posterior (beak) end; (h) hinge line; (ca) cardina area; (e) cardinal extremities; (dt) deltidium; (u) umbo; (a) apex or beak

with a central perforation from which radiate a number of ridges, giving the cells often a radiately septate appearance; mesopores single, in groups or encircling the apertures.

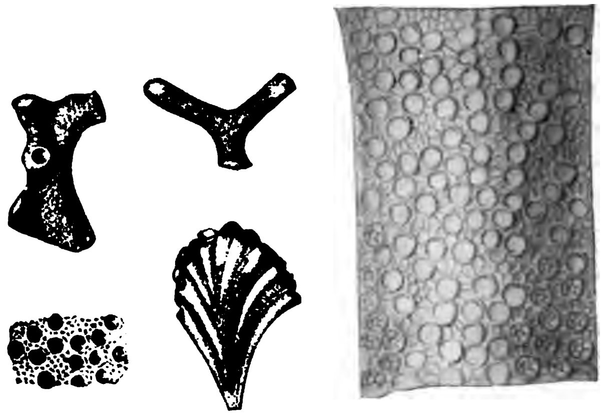


Fig. 67 Callopora elegantula with enlargements of surface, and individual tubes

Found abundantly in the Bryozoa beds of the Rochester shale at Niagara. Also common at Lockport (Hall).

Genus PHYLLOPORINA Ulrich

[Ety.: φύλλον, leaf; πόρος, pore]

(1890. *Geol. sur. Illinois*, 8:399, 639)

Zoarium branching, with branches irregularly anastomosing, with two to eight rows of apertures on one side, longitudinally striated on the other; zooecia more or less tubular, often with diaphragms, and generally separated by tabulated interstitial spaces, which are closed at the surface; acanthopores often present.

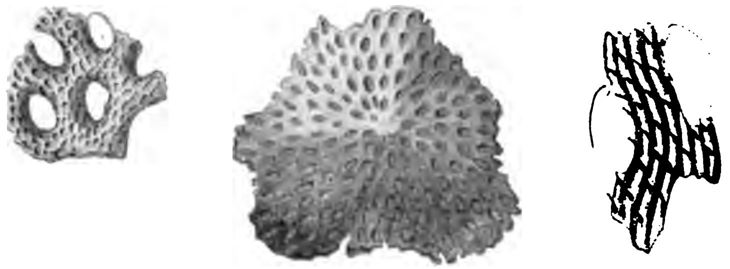


Fig. 68 Phylloporina asperato-striata with enlargement of celluliferous and non-celluliferous faces, the latter showing the asperate-striate character

Genus PHOLIDOPS Hall

[Ety.: *φολίς*, a scale]

(1859. *Pal. N. Y.* 3:489; 1892. *Pal. N. Y.* v. 8, pt 1, p. 155)

Shells small, with equal valves, patella-like in outline; inarticulate and unattached, without pedicle opening; position of apex variable; edges of valves flattened where they meet, and on the interior are elevated areas for attachment of muscles, etc. In molds of the interior, a strongly marked impression of this callosity appears.

Pholidops squamiformis Hall (Fig. 82). Orbicula ? squamiformis Hall (1852. *Pal. N. Y.* 2:250, pl. 53, fig. 4a-b)

Distinguishing characters. Depressed oval form; squamous concentric striae, most marked on anterior slope.

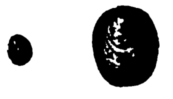


Fig. 82 Pholidops squamiformis natural size and enlarged

Found near the middle of the lower Rochester shales at Niagara. Also at Lockport (Hall).

Genus DICTYONELLA Hall

[Ety.: *δικτύον*, net]

(1867. *N. Y. state cab. nat. hist. 20th an. rep't*, p. 274; 1893. *Pal. N. Y.* v. 8, pt 2, p. 307)

Shell subtriangular in outline with biconvex valves, pedicle valve having a broad median sinus, and brachial valve a corresponding fold; beak of pedicle valve acute and arched over that of brachial valve, though not closely appressed against it; a short, triangular deltidium depressed within the cavity of the pedicle valve; teeth long, marginal and ridge-like on the diverging cardinal slopes and fitting into narrow marginal grooves on the brachial valve; brachial valve with a strong median septum. Exterior covered by a coarse network of superficial cells, usually hexagonal, sometimes circular in outline. A triangular area at the umbo of the pedicle valve is destitute of this reticulation.

Dictyonella corallifera Hall (Fig. 83). Atrypa corallifera Hall (1852. *Pal. N. Y.* 2:281, pl. 58, fig. 5a-t)

Distinguishing characters. Form rhomboidal to subtriangular, base often nearly straight; broad and strong sinus and fold; reticulated or pitted surface, the space between the pits often punctate.

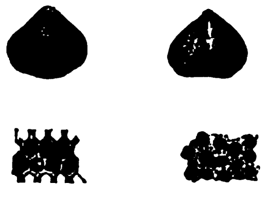


Fig. 83 Dictyonella corallifera with surface enlarged

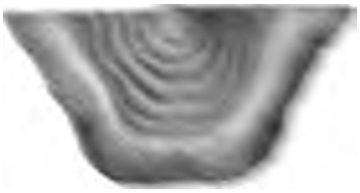
Found in the Bryozoa beds of the Rochester shale at Niagara. Also at Lockport (Hall).

[illegible]

[illegible]

[illegible]

[illegible] concentric [illegible] of the valves. [illegible] abruptly deflected. [illegible] covered with [illegible] preserved specimens are [illegible] straight cardinal [illegible] terminated at the apex [illegible] which often en- [illegible] the apex of the valve. [illegible] cardinal process and [illegible] muscular impressions [illegible] present.



Leptaena rhomboidalis Wah- [illegible] Leptaena [illegible] *Pal.* [illegible]

[illegible] Cor- [illegible] convex to [illegible] concentric cor- [illegible] lenses, and [illegible] bed. Rarely [illegible]

[illegible]

[illegible]

[illegible] N. Y. v. 8, pt 1, p. 284

Shell normally concavo-convex. Hinge line usually equal to or greater than the greatest width of the shell. Area of the pedicle valve higher than that of the brachial valve, both furnished with projecting denticulations, which interlock and form articulations. Muscular areas well marked and variously bounded. A strongly marked bifid cardinal process occurs in the brachial valve.

Stropheodonta corrugata (Conrad) (Fig. 85) (Hall. 1852. *Pal. N. Y.* 2:59, pl. 21)

Distinguishing characters. Semioval, nearly flat; small, acute lateral extensions of hinge; fine, prominent striae sometimes bifurcating or alternating with finer ones; oblique folds on hinge margin.

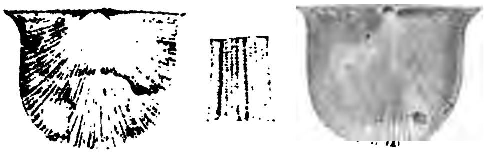


Fig. 85 Stropheodonta corrugata; with surface enlarged

Found in the Clinton limestone (?) and the Clinton lenses at Niagara. Rare.

Stropheodonta profunda Hall (Fig. 86) (1852. *Pal. N. Y.* 2:61, pl 21)

Distinguishing characters. Large, semioval, much wider than high; auriculate hinge; profoundly concave brachial valve; abruptly deflected margins; fine, unequal surface striae; papillose or punctate interior.

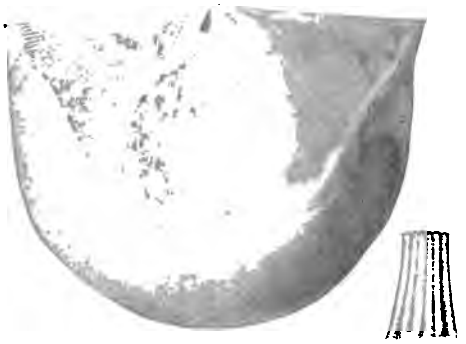


Fig. 86 Stropheodonta profunda with enlargement of striae

Found in the lower and upper Clinton limestone at Niagara. Also in the latter bed at Lockport (Hall).

Genus STROPHONELLA Hall

[Ety.: στρόφος, turned around]

(1879. *N. Y. state mus. nat. hist., 26th an. rep't*, p. 153; Hall & Clarke. 1892. *Pal. N. Y.* v. 8, pt 1, p. 290)

Shells with the form and structure of Stropheodonta, but with the relative convexity of the valves reversed.

Strophonella striata Hall (Fig. 87) Leptaena striata Hall (1852. *Pal. N. Y.* 2:259, pl. 53, fig. 7)

Fig. 87 Strophonella striata

Distinguishing characters. Semielliptic, almost flat, hinge line equal to or a little longer than width of shell; fine, rounded, radiating surface striae, which increase by implantation; fine concentric striae.

Found in the middle and upper Rochester shale at Niagara.

Strophonella (?) patenta Hall (Fig. 88). Leptaena patenta Hall (1852. *Pal. N. Y.* 2:60, pl. 21)

Distinguishing characters. Wider than high; hinge not auriculate; fine unequal radii crossed by finer concentric striae; inner surfaces of valves thickly covered with sharp points.

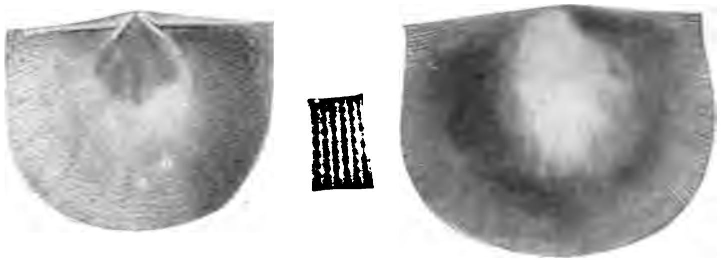


Fig. 88 Strophonella (?) patenta with enlarged surface features

Found in the Clinton limestones and lenses and doubtfully in the middle Rochester shales at Niagara.

Genus PLECTAMBONITES Pander

[Ety.: πλεκτός, plaited; ἄμβων, beak]

(1830. *Beiträge zur Geognosie des Russ. Reiches.* p. 90. Hall & Clarke, 1892; *Pal. N. Y.* v. 8, pt 1, p. 236, 295)

Shells small, concavo-convex; surface striae very fine, often alternating in size; hinge line making greatest width, extremities often subauriculate; cardinal areas narrow, sometimes obscurely crenulated on the margins. Delthyrium partially closed by convex plate, but mostly occupied by cardinal process of opposite valve. Cardinal process appears trilobate. Muscular areas moderately well defined.

Plectambonites sericea (Sowerby) (Fig. 89). Leptaena sericea Hall (1852. *Pal. N. Y.* 2:59, pl. 21)

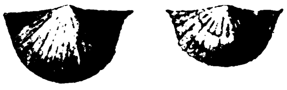


Fig. 89 Plectambonites sericea

Distinguishing characters. Outline semicircular to semioval; hinge line extended, ending in acute points; striae strong, elevated, alternating with finer ones.

Found in the lower Clinton limestone at Niagara. Rare.

Plectambonites transversalis (Wahlenberg) (Fig. 90). Leptaena transversalis Hall (1852. *Pal. N. Y.* 2:256, pl. 53, fig. 5a-b)

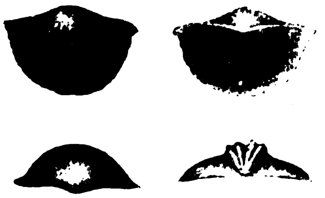


Fig. 90 Plectambonites transversalis

Distinguishing characters. Outline semicircular; strongly convex pedicle, and extremely concave brachial valve, conforming to each other; strongly incurved beak of pedicle valve, which causes an inflection of the hinge line; hinge line produced; fine distant elevated striae with extremely fine striae between; strongly punctate character of exfoliated portions.

Found in the Clinton lenses, and abundantly in the lower Rochester shale at Niagara. Also at Lockport (Hall).

Genus ORTHOTHETES Fischer de Waldheim

[Ety.: ὀρθός, straight]

(1830. *Soc. imp. natural. d. Moscow Bul.* 1:375. Hall & Clarke, 1892; *Pal. N. Y.* v. 8, pt 1, p. 253)

Shell varying from plano-convex to biconvex, sometimes becoming concavo-convex with age. Pedicle valve most convex about the beak, which often tends toward irregular growth; cardinal area well developed, with a thick, more or less convex deltidium. Teeth not supported by dental plates. Brachial valve most convex near the middle, with a narrow hinge area; cardinal process quadrilobate as seen from above. Surface covered by slender radiating striae, which are crenulated by concentric lines.

Orthothetes subplanus (Conrad) (Fig. 91). Leptaena subplana Hall (1852. *Pal. N. Y.* 2:259, pl. 53, fig. 8-10)

Distinguishing characters. Pedicle valve at first convex, later becoming concave; valves nearly equal in length and width; extended hinge line, sometimes projecting into points; sharp angular or subangular to rounded striae, sometimes bifurcating before reaching margin, separated by wider interspaces; the usual method of increase is by intercalation of fine striae, which soon grow to strength of the chief ones; fine concentric and occasionally coarser lines of growth.

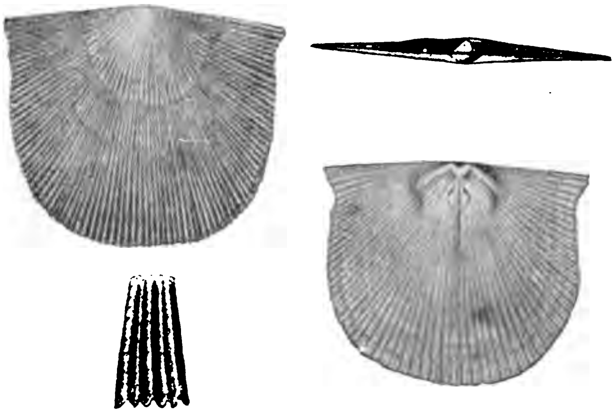


Fig. 91 Orthothetes subplanus

Found at Niagara in the upper Clinton beds and the Clinton lenses; also abundantly in certain thin calcareous layers of the lower Rochester shale, less common in the middle and upper shale. Also at Lockport and elsewhere (Hall).

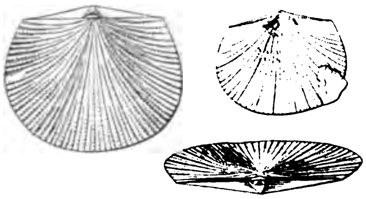


Fig. 92 Orthothetes hydraulicus

Orthothetes hydraulicus (Whitfield) (Fig. 92) (Grabau. *Geol. soc. Am. Bul.* 11:365, pl. 22)

Distinguishing characters. Small size; obtuse cardinal margins with hinge line shorter than greatest width of shell; uniformly rounded front; strong rounded, sharply defined radiating striae, which curve slightly upward on the lateral margins near the cardinal area; strongest striae reaching to beak; increase by repeated intercalation; fine concentric striae.

Found in great abundance in the Manlius limestone of North Buffalo, etc., usually in the condition of molds.

Genus CHONETES Fischer de Waldheim

[Ety.: χώνη, funnel]

(1837. *Oryctographie du gouv. de Moscow*, pt 2, p. 134; 1892. *Pal. N. Y.* v. 8, pt 1, p. 303)

Shells concavo-convex (in our species), with the pedicle valve convex; hinge line straight, making the greatest diameter of the shell; areas narrow; the triangular opening (delthyrium) in the area of the pedicle valve covered by a convex deltidium. Upper margin of area bears a single row of hollow spines. Area of brachial valve without spines; cardinal process appearing quadrilobate. Interior of shell strongly papillose in the pallial region. A low median ridge divides the muscular area of the pedicle valve. A similar ridge occurs in the brachial valve. External surface usually covered by radiating striae.

Chonetes cornutus (Hall) (Fig. 93) (1852. *Pal. N. Y.* 2:64, pl. 21)

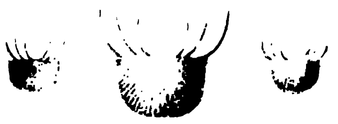


Fig. 93 Chonetes cornutus natural size and enlarged

Distinguishing characters. Semicircular; fine equal striae, round, straight and bifurcating with similar interspaces; three cardinal spines on each side of beak, obliquely diverging below, curving inward at middle and upper parts; outer one longest.

Found (doubtfully) in the Lockport limestone at Niagara.

Genus ORTHIS Dalman

(*sensu strictu*)

[Ety.: ὀρθός, straight; in allusion to hinge line]

(1828. *Kongl. Svenska Vet. Akad. Handl.* p. 93, 96. Hall & Clarke 1892; *Pal. N. Y.* v. 8, pt 1, p. 192)

Shells plano-convex in contour; costae strong, sharp and comparatively few, rarely if ever bifurcating; cardinal area of pedicle valve elevated and somewhat incurved; dental lamellae slightly developed, not extending the entire length of the umbonal cavity. Cardinal process an elongate vertical plate, logitudinally dividing the deep deltidial cavity.

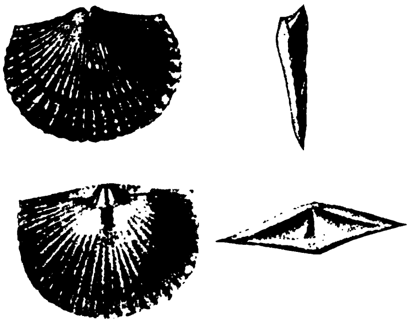


Fig. 94 Orthis flabellites

Orthis flabellites Foerste (Fig. 94). Orthis flabellulum var. Hall (1852. *Pal. N. Y.* 2:254, pl. 52)

Distinguishing characters. Long hinge line; semioval form; coarse, simple rounded plications, equal to spaces between them; marked concentric growth lines.

Found in the upper Clinton limestone and the lower Rochester shale at Niagara. Rare. Also in the shale at Lockport (Hall).

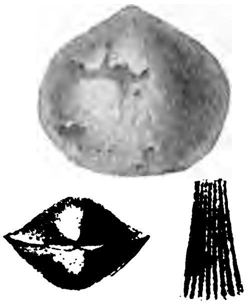


Fig. 95 Orthis (?) punctostriata with enlargement of surface

Orthis (?) punctostriata Hall (Fig. 95) (1852. *Pal. N. Y.* 2:254, pl. 52, fig. 5a-f)

Distinguishing characters. Subglobose contour, nearly equal, extremely convex valves; beak of pedicle valve somewhat longer than that of brachial valve, but both prominent; short hinge line, still shorter but high area; fine equal bifurcating striae; extremely fine concentric striae; punctate interspaces.

Found in the talus of Rochester shale above Lewiston hights. Rare. Also in the shale at Lockport (Hall).

Genus ORTHOSTROPHIA Hall

[Ety.: the name refers to the relations of the genus to Orthis and Stropheodonta]

(1883. *N. Y. state geol. 2d an. rep't,* pl. 36; 1892. *Pal. N. Y.* v. 8, pt 1, p. 199, 223, 253)

Shells with convexity of valves reversed; surface finely plicated; deep narrow muscular area; cardinal process elongate and simple.

Orthostrophia (?) fasciata Hall (Fig. 96). Orthis fasciata Hall (1852. *Pal. N. Y.* 2:255, pl. 52)

Distinguishing characters. Semi-oval contour; produced hinge line; clustered or fasciculated striae almost simple at their origin, dividing toward the margin.

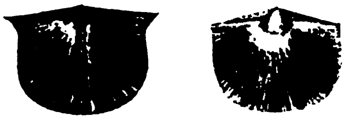


Fig. 96 Orthostrophia (?) fasciata

Found in the lower Rochester shale at Niagara (?). Also at Lockport (Hall).

Genus DALMANELLA Hall & Clarke

[Ety.: proper name]

(1892. *Pal. N. Y.* v. 8, pt 1, p. 205, 223)

Shells plano-convex or subequally biconvex; pedicle valve usually the deeper, often elevated at the umbo and arched over the cardinal area; hinge line generally shorter than the greatest width of the shell; surface finely striate. Prominent teeth supported by lamellae which circumscribe the muscular area; cardinal process tri- to quadrilobed, continued downward in a median ridge dividing a quadriplicate muscular area.

Dalmanella elegantula (Dalman) (Fig. 97). Orthis elegantula Dalman (Hall 1852. *Pal. N. Y.* 2:252, pl. 52, fig. 3a-r)

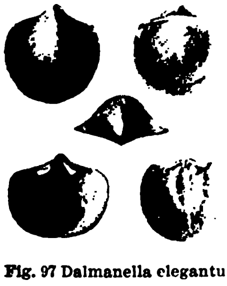


Fig. 97 Dalmanella elegantula

Distinguishing characters. Strongly convex pedicle valve with high but narrow area and incurved beak; nearly flat brachial valve; generally with a longitudinal concavity in the center; fine close set striae, which divide dichotomously toward the margin; extremely fine concentric lines and coarser growth lines.

Found in the Clinton lenses, and abundantly at intervals in the lower and middle (Bryozoa beds) Rochester shales at Niagara. Also at Lockport and elsewhere (Hall).

Genus **RHIPIDOMELLA** Oehlert

[Ety.: ῥιπίς, fan]

(1891. *Journal de conchyliologie.*, p. 372; 1892. *Pal. N. Y.* v. 8, pt 1, p. 209)

Shell almost circular in outline; both valves gently convex; hinge area short; slight median depression in each valve. Surface covered with fine, rounded, hollow, tubular striae, which frequently open on the surface. On the interior of the pedicle valve are two strong diverging teeth. Muscular area large, and deeply impressed, consisting of fluted diductor impressions, inclosing small central adductors. The pedicle scar fills the cavity of the beak. The interior of the brachial valve shows deep and narrow dental sockets, with prominent projecting crural plates. In the center is a strong cardinal process, below which is the indistinct small muscular area.

Rhipidomella hybrida (Sowerby) (Fig. 98). Orthis hybrida Sowerby (Hall. 1852. *Pal. N. Y.* 2:253, pl. 52)

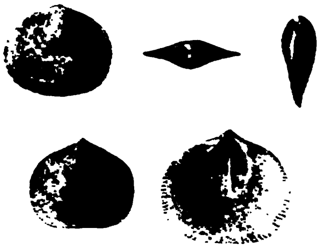


Fig. 98 Rhipidomella hybrida

Distinguishing characters. Wider than long; nearly equal valves; pedicle valve with broad, undefined depression down the center; brachial valve uniformly convex, sometimes slightly depressed near front; beaks nearly equally elevated and scarcely incurved; short hinge area; fine bifurcating striae.

Found in the upper part of the lower Rochester shales and in the Bryozoa bed as well as rarely in the upper shales. Niagara sections. Also at Lockport and elsewhere (Hall).

Rhipidomella circulus Hall (Fig. 99). Orthis circulus Hall (1852. *Pal. N. Y.* 2:56, pl. 20)

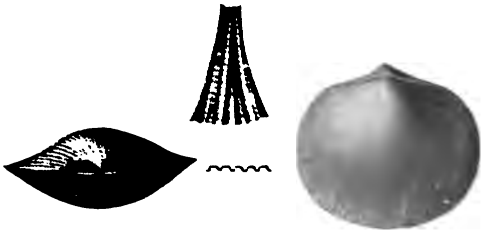


Fig. 99 Rhipidomella circulus with enlargement of surface

Distinguishing characters. Nearly circular and equivalve; finely striated surface; dichotomous striae running upward and outward on the hinge line; narrow short hinge area; slightly sinuous front.

Found in the lower Clinton limestone (?). Also east of Lockport (Hall).

Genus SCENIDIUM Hall

[Ety.: *σκηνίδιον*, little tent]

(1860. *N. Y. state cab. nat. hist. 13th rep't*, p. 70; 1892. *Pal. N. Y.* v. 8, pt 1, p. 241)

Shells subpyramidal, somewhat semicircular; with or without median sinus or elevation; pedicle valve elevated, subpyramidal; beak straight or slightly arched; cardinal area large, triangular, divided by a narrow fissure, sometimes closed at the summit by a concave plate. Brachial valve depressed convex to concave; cardinal line usually equal to width of shell; cardinal process simple or divided, and extending as a median septum through the length of the shell. Spondylium in the pedicle valve.

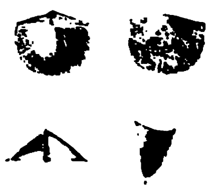


Fig. 100 Scenidium pyramidale enlarged

Scenidium pyramidale Hall (Fig. 100). Orthis pyramidale Hall (1852. *Pal. N. Y.* 2:251, pl. 52, fig. 2a-z)

Distinguishing characters. Minute, subpyramidal; flat semicircular brachial valve, centrally depressed; extremely elevated pedicle valve with large triangular area; strong radiating striae, sometimes dichotomous; lamellose concentric striae.

Found in the Rochester shale at Lockport (Hall) and may also occur at Niagara.

Genus ANASTROPHIA Hall

[Ety.: *ἀνά*, back; *στροφή*, a turning]

(1867. *N. Y. state cab. nat. hist. 20th an. rep't*, p. 163; 1893. *Pal. N. Y.* v. 8, pt 2, p. 224)

Pentameroid shells with a spoon-shaped cavity (spondylium) under the beak of the pedicle valve and with a moderate cardinal line but no hinge area; surface with numerous sharp plications extending to the beak.

Anastrophia interplicata (Hall) (Fig. 101). Atrypa interplicata Hall (1852. *Pal. N. Y.* 2:275, pl. 57)

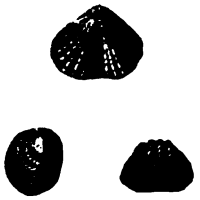


Fig. 101 Anastrophia interplicata

Distinguishing characters. Extremely convex; brachial valve the deepest; moderate sinus and fold; from two to three plications in the former and three to four on the latter; lateral plications increase by implantation.

Found in the Clinton lenses, and in the lower and middle Rochester shale at Niagara. Also in the shale at Lockport (Hall).

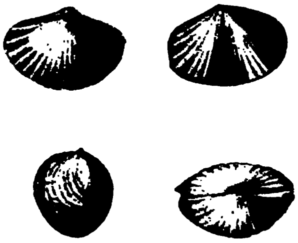


Fig. 102 Anastrophia brevirostris

Anastrophia brevirostris Hall (Fig. 102) Atrypa brevirostris Hall (1852. *Pal. N. Y.* 2:278, pl. 58)

Distinguishing characters. Wider than high; strongly convex; brachial valve deepest; short nearly equal beaks; sharp bifurcating or interpolated plications, from five to six in the sinus and fold, which are broad and ill defined.

Found in the lower Rochester shale at Niagara (?). Also in the shale at Lockport (Hall).

Genus PENTAMERUS Sowerby

[Ety.: πέντε, five; μέρος, part]

(1813. Sowerby. *Mineral conchology*, 1:76; Hall & Clarke. 1893. *Pal. N. Y.* v. 8, pt 2, p. 236)

Shell strongly inequivalve, biconvex with highly arched pedicle valve; surface smooth, or with a few broad and obscure radiating undulations. Under the beak of the pedicle valve is a deep and narrow *spondylium*, or plate with an excavated spoon-shaped cavity, supported by a high vertical septum of variable length; brachial valve with a pair of septa, the interior of the shell being thus divided into five compartments.

Pentamerus oblongus Sowerby (Fig. 103) (Hall. 1852. *Pal. N. Y.* 2:79, pl. 25)

Distinguishing characters. Very large and oblong, varying in outline with age; wider in anterior part; valves strongly convex at beaks; beak of pedicle valve overarching; subtrilobate division of valves in some specimens; surface marked only by concentric lines of growth, which are strongest in old shells.

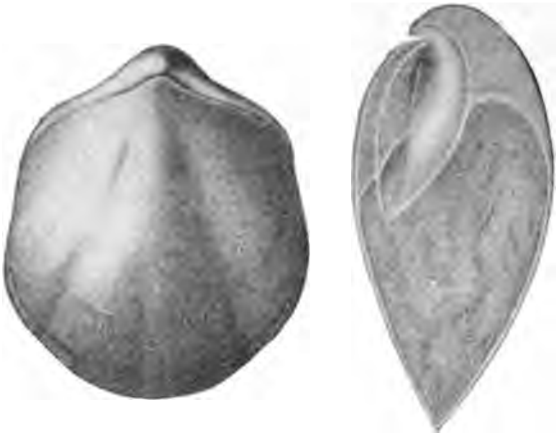


Fig. 103 Pentamerus oblongus

Found in the upper crystalline Clinton limestone at Niagara (1 specimen). The species is characteristic of the lower Clinton limestone, east of Lockport.

Genus BARRANDELLA Hall & Clarke

[Ety.: proper name]

(Hall & Clarke. 1894. *Pal. N. Y.* v. 8, pt 2, p. 241, 243)

Small pentameroid shells, of a galeate form or helmet-shaped contour, with a smooth, or rarely plicated surface. A spondylium is present, but is not supported by a septum.

Barrandella fornicata (Hall) (Fig. 104). Pentamerus fornicatus Hall (*Pal. N. Y.* 2:81, pl. 24)

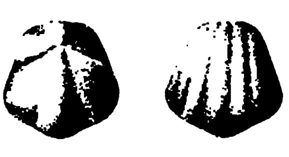


Fig. 104 Barrandella fornicata

Distinguishing characters. Helmet-shaped contour, very convex pedicle valve, with overarching beak; surface obscurely plicate longitudinally.

Found in the upper crystalline Clinton limestone at Niagara. Also in the same limestone at Lockport (Hall).

Genus RHYNCHOTRETA Hall

[Ety.: *ῥύγχος*, beak; *τρητά*, with a hole]

(1879. *N. Y. state mus. nat. hist. 28th an. rep't*, p. 166; 1893. *Pal. N. Y.* v. 8, pt 2, p. 185)

Shell triangular; surface with angular plications. Beak of pedicle valve straight, produced beyond that of the opposite valve, extremity perforate, the foramen with an elevated margin. Two longitudinally striated deltidial plates fill the delthyrium. Teeth slender, curving, proceeding from a broad curving hinge plate in the pedicle valve. Brachidium a slightly modified loop.

Rhynchotreta cuneata var. **americana** Hall (Fig. 105). Atrypa cuneata Hall (1852. *Pal. N. Y.* 2:276, pl. 57, fig. 4a-r)

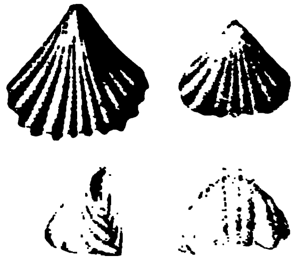


Fig. 105 Rhynchotreta cuneata var. americana

Distinguishing characters. Triangular and cuneiform outline; longer than wide; elongate angular beak of pedicle valve with compressed, flat or concave sides; wide, deep sinus in adult, extending two thirds to the beak; profound frontal emargination; strong angular plications, three in sinus, four on fold, the two central ones most prominent; numerous regular, fine thread-like concentric striae; minutely papillose surface.

Found in the Clinton lenses and the lower Rochester shale and particularly in the Bryozoa beds, where it is abundant; rarely above this. Niagara sections. Also at Lockport and elsewhere (Hall).

Genus CAMAROTOECHIA Hall & Clarke

[Ety.: *καμάρα*, arched chamber; *τοῖχος*, partition]

(1893. *Pal. N. Y.* v. 8, pt 2, p. 189)

Shell rhynchonelloid, trihedral in contour, with shallow pedicle and convex brachial valve; no hinge area; beak of pedicle valve projecting and incurved. Surface radially plicate, sinus and fold in pedicle and brachial valves respectively. Distinctive internal characters (separating this genus from other "Rhynchonellas") are: a median septum in the brachial valve, which divides posteriorly, so far as to form an elongate cavity, which does not extend to the bottom of the valve. No cardinal process. In the pedicle valve slender vertical lamellae support the teeth.

Camarotoechia obtusiplicata Hall (Fig. 106). Atrypa obtusiplicata Hall (1852. *Pal. N. Y.* 2:279, pl. 58, fig. 2a-h)

Distinguishing characters. Gibbous, subspheroidal form; strongly convex brachial, and flatter pedicle valve; deep sinus of pedicle valve with three plications (rarely four); depressed incurved beak of pedicle valve; simple, obtusely rounded or flattened plications; faint concentric striae; strongly emarginate front.

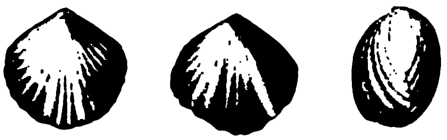


Fig. 106 Camarotoechia obtusiplicata

Found in the lower part of the lower Rochester shales at Niagara. Also in the shales and limestones at Lockport (Hall).

Camarotoechia (?) neglecta Hall (Fig. 107). Atrypa neglecta Hall (1852. *Pal. N. Y.* 2:70, 274, pl. 23 and 57)

Distinguishing characters. Convex valves, brachial valve deepest, sides sloping abruptly to the beak; strongly defined sinus and fold, in adult individual, the former with three, the latter with four plications; profound frontal emargination; plications rounded.

Found in the lower Clinton limestone in the Clinton lenses and in the upper part of the lower and the middle Rochester shales at Niagara. Also more rarely in the upper shales. Found also at Lockport and elsewhere (Hall).

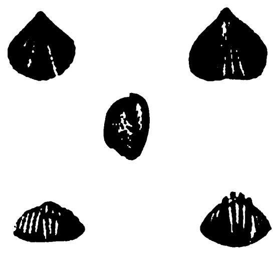


Fig. 107 Camarotoechia (?) neglecta

Camarotoechia acinus Hall (Fig. 108). Rhynchonella acinus Hall (*N. Y. state mus. nat. hist. 28th an. rep't*, p. 163, pl. 26)

Distinguishing characters. Small size; longitudinally ovate form, narrowing toward beak, truncate in front; subequally convex valves;

a single plication in sinus of pedicle valve and two on fold of brachial valve; few plications on either side of fold or sinus.

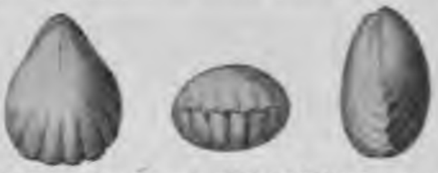


Fig 108 Camarotoechia acinus. A specimen in which the fold and sinus are not developed. Enlarged x 4

Found in the crystalline upper Clinton limestone at Niagara. The species was originally described from the western Niagara.

Genus RHYNCHONELLA Fischer de Waldheim

[Ety.: ῥύγχος, beak]

(1809. *Notice des fos. gouv. Moscou.* p. 35; Hall & Clarke. 1893. *Pal. N. Y.* v. 8, pt 2, p. 177, 178)

Subpyramidal plicated shells with a prominent anterior linguiform extension. Dental lamellae and a dorsal median septum occur, but no cardinal process; crura are present, but other arm supports are wanting.

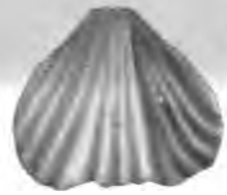


Fig. 109 Rhynchonella robusta

Rhynchonella robusta Hall (Fig. 109). Atrypa robusta Hall (1852. *Pal. N. Y.* 2:71, pl. 23)

Distinguishing characters. Large size; robust character; brachial valve most convex; broad, ill defined fold and sinus; coarse rounded plications.

Found in the uppermost beds of the Clinton series at Niagara. Also east of Lockport (Hall).

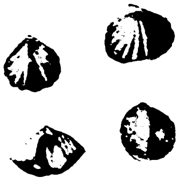


Fig. 110 Rhynchonella (?) bidens

Rhynchonella (?) bidens Hall (Fig. 110). Atrypa bidens Hall (1852. *Pal. N. Y.* 2:69, pl. 23)

Distinguishing characters. Much smaller than preceding; strong convexity of valves; deep sinus with one plication; fold consisting of two rounded plications; rather broad, rounded lateral plicae; strongly emarginate front.

Found in the lower Clinton beds at Lockport (Hall). Probably also at Niagara.

Rhynchonella (?) bidentata (Hisinger) (Fig. 111). Atrypa bidentata Hall (1852. *Pal. N. Y.* 2:276, pl. 57)

Distinguishing characters. Triangular form; acute, extended beak of pedicle valve; stronger convexity of brachial valve; less convex and more triangularly acute than preceding; very slight frontal emargination; shallow sinus with one plication, and corresponding fold with two.

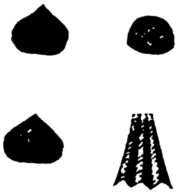


Fig. 111 Rhynchonella (?) bidentata with surface enlarged

Found in the Rochester shale at Lockport and elsewhere (Hall). Probably also at Niagara.

Genus ATRYPA Dalman

[Ety.: α, without; τρύπα, foramen (erroneous)]

(1828. *Kongl. Vetenskaps Akad. Handlingar*, p. 127; 1894. *Pal. N. Y.* v. 8, pt 2, p. 163)

Shell varying in outline from nearly circular to longitudinally suboval; valves very unequal, brachial valve being strongly convex or gibbous, while the pedicle valve is gently convex or almost flat or sometimes slightly concave from the strongly marked sinus; beak of the pedicle valve small and incurved over that of the brachial. Large widely separated and doubly grooved teeth are present, unsupported by lamellae. Strong muscular impressions. Spirals of the brachidium with their bases parallel to the inner surface of the pedicle valve, and the apexes directed toward the deepest point of the opposite valve. Surface radially plicate.

Atrypa reticularis (Linnaeus) (Fig. 112) (1852. *Pal. N. Y.* 2:272, pl. 23, p. 270, pl. 55)

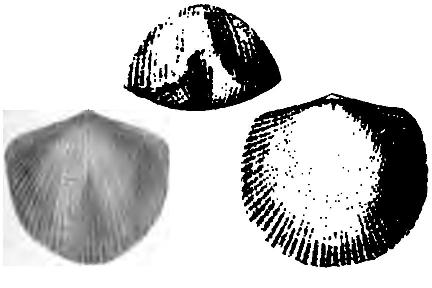


Fig. 112 Atrypa reticularis

Distinguishing characters. Convex brachial and flat pedicle valves; small deeply incurved beaks; radiating and concentric striae forming reticulated surface.

being almost flat. Strong sinus and fold in adult, with minor plications on each; strong concentric rugose lamellae; plications less rounded than preceding.

Found in the Clinton and Rochester beds at Niagara, generally associated with the preceding but much less common. Also at Lockport, etc. (Hall).

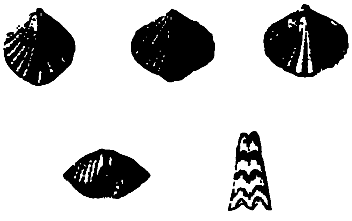


Fig. 114 Atrypa rugosa with striae enlarged

Genus CYRTINA Davidson

[Ety.: *κυρτία*, a wicker shield]

(1858. *British Carbon. Brachiopoda.* Monograph, p. 66; 1893. *Pal. N. Y.* v. 8, pt 2, p. 43)

Shells Spirifer-like; usually small; valves very unequal; pedicle valve elevated, with a high cardinal area, the delthyrium of which is covered by an elongate, convex pseudodeltidium, which is perforated below the apex; surface plicate. Dental lamellae strong, converging rapidly, and meeting a median septum. Cardinal process a double apophysis. Brachidium an extroverted spire.

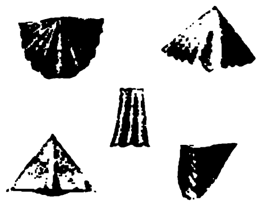


Fig. 115 Cyrtina pyramidalis with striae enlarged

Cyrtina pyramidalis (Hall) (Fig. 115). Spirifer pyramidalis Hall (1852. *Pal. N. Y.* 2:266, pl. 54)

Distinguishing characters. Pyramidal form; vertical or slightly bent area; nearly flat brachial valve; extremely convex pedicle valve; subangular plications, about five on each side of mesial fold and sinus.

Found "near the top and just below the edge of the cliff on the Niagara river above Lewiston" (Hall).

Genus SPIRIFER Sowerby

[Ety.: *spira*, spire; *fero*, to bear]

(1815. *Mineral conchology*, 2:42; 1894. Hall & Clarke. *Pal. N. Y.* v. 8, pt 2, p. 1)

Shell variously shaped, commonly very much wider than long, radially plicated or striated, crossed by concentric growth lines, which in some forms are lamellose or even marked by spines.

Hinge line generally long and straight; pedicle valve usually with moderately high area, with an open delthyrium, the margins of which are prolonged into stout simple teeth, supported by dental lamellae. Area of the brachial valve the lower. A calcareous brachidium in the form of a double spire, whose apexes are directed toward the cardinal angles, nearly fills the cavity of the shell.

Spirifer radiatus Sowerby (Fig. 116) (Hall. 1852. *Pal. N. Y.* 2:66, pl. 22, p. 265, pl. 54)

Distinguishing characters. Moderately large size; pedicle valve with strongly incurved beak, moderate area, and broad shallow mesial sinus; flattened median fold; fine uniform radiating striae covering all parts of the shell.

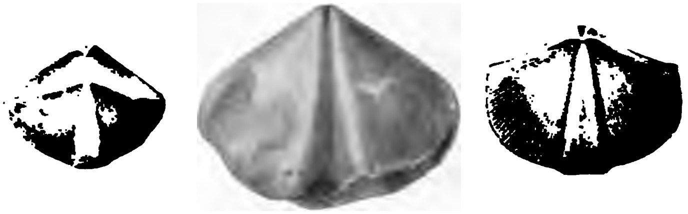


Fig. 116 Spirifer radiatus showing variation

Found in the Clinton limestones and lenses and in the lower and middle Rochester shales at Niagara; sometimes abundant. Also at Lockport and elsewhere (Hall).

The shell varies greatly in form and proportions; sometimes the hinge area is much extended or the hinge extremities are rounded and the hinge line shorter than the shell below. Faint plications near the fold and sinus also occur in some specimens, connecting this species with the next.

Spirifer niagarensis Conrad (Fig. 117) (Hall. 1852. *Pal. N. Y.* 2:264, pl. 54)

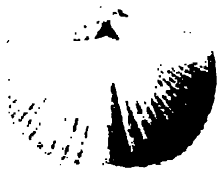


Fig. 117 Spirifer niagarensis

Distinguishing characters. Moderately large size; convex, with nearly equal valves; strongly incurved beak of pedicle valve; moderate area; numerous fine, rounded, depressed plications, which become obsolete toward the extremities, and sometimes appear quite flattened out on the surface; fine thread-like radiating striae covering plications and interspaces alike.

Found in the upper Clinton limestone and the Clinton lenses and abundantly throughout the lower and middle Rochester shale at Niagara. Also at Lockport and elsewhere (Hall).

Spirifer crispus (Hisinger) (Fig. 118) (Hall. 1852. *Pal. N. Y.* 2:262, pl. 54)

Distinguishing characters. Small size; very convex pedicle valve with incurved beak and high area, which does not extend to cardinal extremities; broad rounded plications, from six to eight on each valve, strongest near the fold and sinus; fine, elevated, thread-like concentric striae.

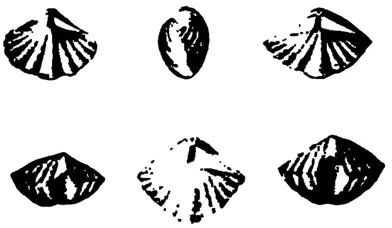


Fig. 118 Spirifer crispus

Found in the Clinton lenses and the lower and particularly the middle Rochester shale (Bryozoa beds) at Niagara. Also at Lockport and elsewhere (Hall).

Spirifer crispus var **corallinensis** Grabau. (*Geol. soc. Am. Bul.* 11:352; Hall. 1852. *Pal. N. Y.* 2:328, pl. 74, fig. 9a-h)

Distinguishing characters. Uniformly obsolescent plications, angular mesial sinus; otherwise like preceding.

Found in the Clinton lower limestone, the lenses, and the lower Rochester shale. Not abundant. This variety connects S. crispus with S. eriensis. It is characteristic of the Coralline limestone of eastern New York.

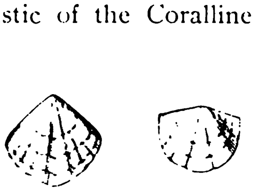


Fig. 119 Spirifer eriensis

Spirifer eriensis Grabau (Fig. 119) (*Geol. soc. Am. Bul.* 2:366, pl. 21)

Distinguishing characters. Ventricose pedicle valve, of subrhomboidal outline, high area, pronounced angular mesial sinus uniformly increasing in width forward, strong frontal emargination; sinus bounded by strong rounded prominent plications, with fainter ones on either side; linear interspaces; sharply defined fold of brachial valve, with plications almost obsolete.

Found only in the Manlius limestone of North Buffalo and Williamsville. Not common.

Spirifer (Delthyris) sulcatus Hall (Fig. 120) (1852. *Pal. N. Y.* 2:261, pl. 54)

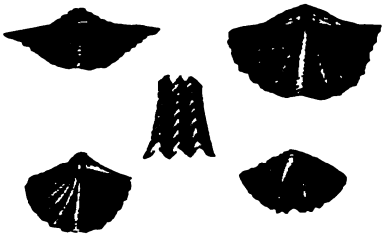


Fig. 120 Spirifer (Delthyris) sulcatus with striae enlarged

Distinguishing characters. Nearly equal valves; deep mesial sinus; four or more plications on either side, with wide interspaces; fine radiating striae crossing plications and interspaces; very coarse, lamellose, subequally spaced concentric growth lines which interrupt the radiating striae.

Found rarely in the Clinton lenses and the lower Rochester shale; more common in the Bryozoa beds at Niagara. Also at Lockport and elsewhere (Hall).

Genus HOMOEOSPIRA Hall & Clarke

[Ety.: ὅμοιος, like; σπεῖρα, spire]

(1893. *Pal. N. Y.* v. 8, pt 2, p. 112)

Shell rostrate, radially plicate, and with a short curved hinge line; apex truncated by a circular pedicle opening. Spirals spiriferoid, with from six to nine volutions and a V-shaped jugum. A linear cardinal process separates the crural plates.

Homoeospira apriniformis Hall (Fig. 121). Atrypa aprinis Hall (1852. *Pal. N. Y.* 2:280, pl. 57)

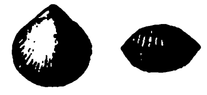


Fig. 121 Homoeospira apriniformis

Distinguishing characters. Small, roundish, oval, scarcely longer than wide; nearly equally convex valves; nonsinuate front, numerous simple rounded plications; fine concentric striae.

Found in the Rochester shale at Lockport (Hall). Probably also at Niagara.

Genus TREMATOSPIRA Hall

[Ety.: τρῆμα, foramen; σπεῖρα, spire]

N. Y. state *mus. nat. hist. 12th an. rep't*, p. 27; 1893. *Pal.* pt 2, p. 124)

transverse, with subequally convex valves; surface radially nge line straight, cardinal extremities abruptly rounded; argin sinuate. Pedicle valve with a median sinus and an beak, truncated by a circular foramen. Delthyrium cov- two short incurved plates, which are usually closely an- and appear continuous, with a narrow, flattened area on lower half of the delthyrium open, for the reception of of the brachial valve. Teeth prominent, arising from the the valve; above the hinge line they curve backward and each other, thus making a very firm articulation. Muscular ell defined. Brachial valve with median fold, and minute Hinge plate greatly elevated, with a small chilidium resting upper face of plate deeply divided by median longitudinal and more faintly by transverse groove. Dental sockets nd deep, crura broad, thin and comparatively short. Brachi- two spiral cones set base to base, as in Spirifer.

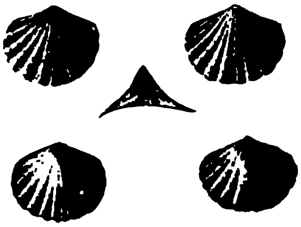


Fig. 122 Trematospira camura

atospira camura Hall (Fig. trypa camura Hall (1852. F. 2:273, pl. 56)

guishing characters. Small; nboidal to transversely elon- early equally convex valves. acute, projecting and slightly in- beak of pedicle valve, showing g shells the ankylosed deltidial plates; strong, distant, simple dar plications, one or two fine ones in the center; fine, like concentric striae and coarse lamellae.

nd in the Bryozoa beds of the Rochester shale at Niagara, ommon. Also at Lockport and elsewhere (Hall).

Genus WHITFIELDELLA Hall & Clarke

[Ety.: proper name]

(1893. *Pal. N. Y.* v. 8, pt 2, p. 58)

usually of small size; valves subequally convex, ovate or outline; beak of pedicle valve not high or greatly incurved, usually exposing the circular apical foramen, beneath which the deltidial plates are frequently retained. Cardinal slopes of both valves broad and not distinctly defined; anterior margin subtruncate and gently sinuate. Hinge plate in brachial valve concave, divided by a deep central concavity, which is supported by a medium septum. Brachidium consisting of two spiral cones arranged base to base, connected by a V-shaped jugum.

Whitfieldella nitida Hall (Fig. 123). Atrypa nitida Hall (1852. *Pal. N. Y.* 2:268, pl. 55)

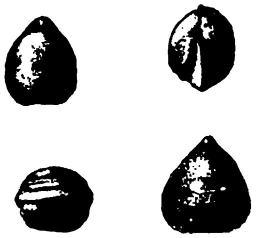


Fig. 123 Whitfieldella nitida

Distinguishing characters. Small size; strong convexity of valves, which are nearly equal, pointed incurved beak of pedicle valve; smooth surface except for concentric growth lines and strong wrinkles of growth; often slight sinus near the front of both valves, causing slight frontal emargination.

Found abundantly in the Clinton lenses and less commonly in the Rochester shale at Niagara.

This species varies from broadly to narrowly ovate; the thickness is frequently greater than the width and coarse thickenings and wrinkles show changes in growth. This may characterize senile individuals.

Whitfieldella nitida var. **oblata** Hall (Fig. 124). Atrypa nitida var. oblata Hall (1852. *Pal. N. Y.* 2:269, pl. 55)

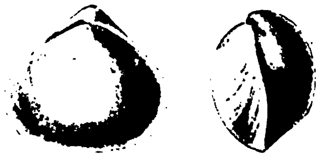


Fig. 124 Whitfieldella nitida var. oblata

Distinguishing characters. Broadly ovate form, angle between cardinal slopes often 90° or more; moderately convex valves, subtriangular in cross-section; uniformly rounded front; surface absolutely smooth, very deep muscular impressions.

Found in the Clinton lenses and the Rochester shale associated with the preceding and usually more abundant. Also at Lockport, etc. (Hall).

Whitfieldella oblata Hall (Fig. 125). Atrypa oblata Hall (1852. *Pal. N. Y.* 2:9, pl. 4)

Distinguishing characters. Oblate form, nearly as broad as high; broadest anteriorly; sloping abruptly to the beak; small, well defined beak; nearly equally convex valves; central groove on pedicle valve and slight elevation on brachial valve; surface marked only by lines of growth.

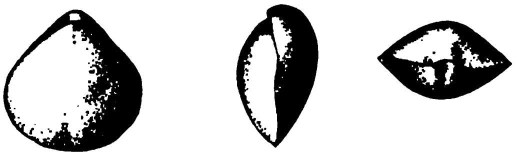


Fig. 125 Whitfieldella oblata

Found in the upper Medina sandstone at Niagara. Also at Lockport (Hall).

Whitfieldella intermedia Hall (Fig. 126). Atrypa intermedia Hall (1852. *Pal. N. Y.* 2:77, pl. 24)

Distinguishing characters. Obovate; rapidly expanding to front, which is abruptly rounded; length and width nearly equal; convex near beak, flatter toward front; slight frontal sinuosity; faint growth lines.

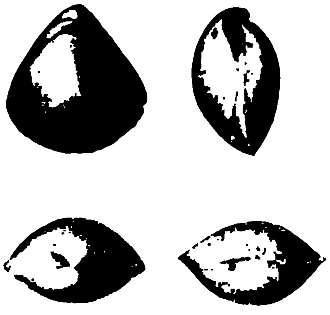


Fig. 126 Whitfieldella intermedia

Found in the Clinton lenses and lowest Clinton shales at Niagara. Also in the upper Clinton limestone at Lockport (Hall).

Whitfieldella cylindrica Hall (Fig. 127). Atrypa cylindrica Hall (1852. *Pal. N. Y.* 2:76, pl. 24)

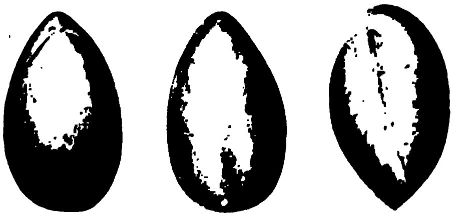


Fig 127 Whitfieldella cylindrica

Distinguishing characters. Elongate cylindric; strongly convex; nearly as wide as thick; strongly overarching beak of pedicle valve;

faint mesial depression in pedicle valve; slight frontal sinuosity; fine radiating striae near the front.

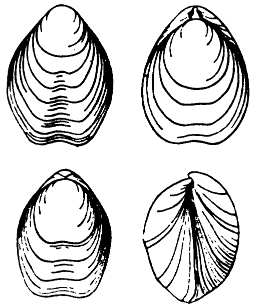


Fig. 128 Whitfieldella sulcata x 1½

Found in the upper Clinton limestone at Lockport (Hall). Probably also at Niagara.

Whitfieldella sulcata (Vanuxem) (Fig. 128) (Grabau. *Geol. soc. Am. Bul.* 11:367, pl. 22)

Distinguishing characters. Ventricose, elongate; well marked sinus in both valves; lines of growth and prominent wrinkles and changes in direction of growth.

Found in the Manlius limestone of North Buffalo, etc.

Whitfieldella rotundata (Whitfield) (Fig. 129) (Grabau. *Geol. soc. Am. Bul.* 11:368, pl. 22)

Distinguishing characters. Small, subcircular; moderately convex; beak curved at right angles to plane of contact of valves.

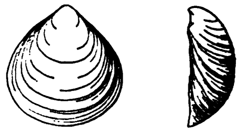


Fig. 129 Whitfieldella rotundata x 1½

Found in the Manlius limestone of Erie county (N. Y.)

Whitfieldella laevis (Whitfield) (Fig. 130) (Grabau. *Geol. soc. Am. Bul.* 11:369, pl. 22)

Distinguishing characters. Small; broadly ovoid; moderately gibbous, greatest gibbosity in posterior third; faint mesial depression.

Found in the Manlius limestone of Erie county (N. Y.)

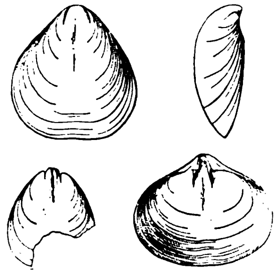


Fig. 130 Whitfieldella laevis x 1½

Genus HYATTELLA Hall & Clarke

[Ety.: proper name]

(1893. *Pal. N. Y.* v. 8, pt 2, p. 61)

Shell similar to Whitfieldella, but compactly subpentahedral, and without the median septum in the brachial valve.

Hyattella congesta (Conrad) (Fig. 131 and 131a). Atrypa congesta Hall (1852. *Pal. N. Y.* 2:67, pl. 23); Atrypa quadricostata Hall (*Pal. N. Y.* 2:68, pl. 23)

Distinguishing characters. Subcircular; gibbous; strongly convex pedicle valve with deep median furrow, deepening and widening forward; frontal linguiform elevation, obtuse carinated fold in sinus; strong fold on brachial valve, with a lateral fold on each side more or less prominent.

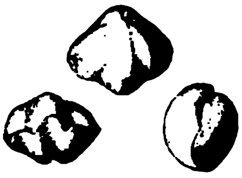


Fig. 131 Hyattella congesta

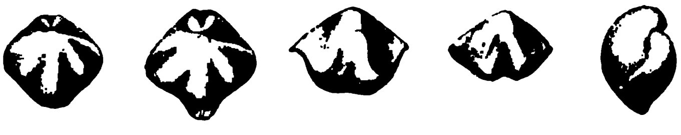


Fig. 131a Hyattella congesta

Found in the lower Clinton limestone at Niagara. Also at Lockport (Hall).

Genus ANOPLOTHECA Sandberger

[Ety.: *ἄνοπλος*, unarmed; *θήκη*, sheath]

(1853. *Sitzb. d. K. K. Akad. d. Wissens. math. naturw. Classe,* 16, p. 5, 18, 102; 1894. Hall & Clarke. *Pal. N. Y.* v. 8, pt 2, p. 129)

Concavo-convex, small shells with few plications crossed by fine often imbricating growth lines. Brachial valve with a high median septum. Brachidium a pair of spiral cones, as in Whitfieldella.

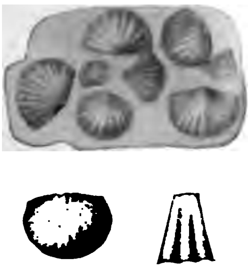


Fig. 132 Anoplotheca hemispherica with striae enlarged

Anoplotheca hemispherica (Sowerby) (Fig. 132). Atrypa hemispherica Hall (1852. *Pal. N. Y.* 2:74, pl. 23)

Distinguishing characters. Hemispheric to semiorbicular form; nearly flat brachial valve, convex pedicle valve; extended, nearly straight hinge line; eight to 12 rounded to subangular, simple plications; strong, undulating concentric striae.

Found poorly preserved in the Clinton shale at Niagara.

Anoplotheca plicatula (Hall) (Fig. 133). Atrypa plicatula Hall (1852. *Pal. N. Y.* 2:74, pl. 23)

Distinguishing characters. Slightly wider than long or sub-rotund; cardinal slopes meeting in obtuse angle; young sheil carinate toward the beak in the pedicle valve; brachial valve gently convex; median fold beginning as a depression at the beak, and becoming elevated near the front; two plications in sinus, three on fold; sharp rounded plications: strong frontal sinuosity; very fine concentric striae.

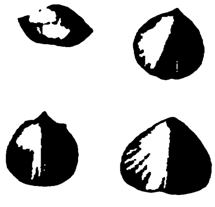


Fig. 133 Anoplotheca plicatula

Found in great abundance in the lower Clinton limestone at Niagara. Also east of Lockport (Hall).

Class PELECYPODA Goldfuss

(Lamellibranchiata Blainville)

The Pelecypoda, or Lamellibranchiata, are marine or fresh-water mollusks, with a bivalve shell. The valves are complementary, and in the majority of species are of nearly similar outline and size. In each valve may be distinguished an initial point, or beak, around which the concentric *lines of growth* mark the successive additions of shelly matter.

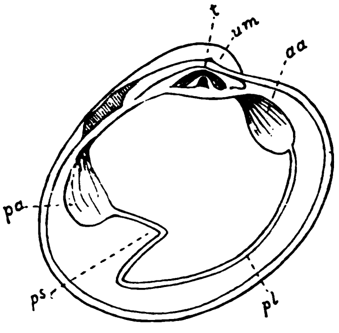


Fig. 134 Diagrammatic view of left valve of Cytherea; (aa) anterior adductor scars; (pa) posterior adductor scars; (pl) pallial line; (ps) pallial sinus; (t) teeth; (um) umbo; (l) ligament

The orientation of most shells is effected by holding them with the *hinge line* uppermost and the beaks pointing away from the observer. Thus placed, the upper is the dorsal and the lower the ventral border. The end farthest away from the observer is the anterior end; that nearest, the posterior end. The valves are designated as the right and left valves respectively. The articulation of the valves is commonly effected by the interlocking of *teeth* which are borne on the hinge or cardinal margin of the valves. They vary greatly, but can usually be divided into the short, stout cardinal teeth, which are situated under or near the beak, and the ridge-like lateral teeth. The opening of the valves is brought about by an elastic ligament stretched across the hinge from valve to valve, behind the beak, which acts, on the principle of the C spring, whenever the tension of the *adductor muscles*, which close the valves, is relaxed. In many genera, an elastic, compressible cartilage, the *resilium* occurs, which is lodged in special grooves or pits. The scars marking the attachment of the adductor or closing muscle or muscles, vary greatly, and are frequently preserved in the fossil forms. When two are present, they are designated, respectively, the anterior and posterior adductor scars. The line of attachment of the fleshy mantle which builds the shells, i. e. the *pallial line*, is often visible. Near the posterior end it frequently makes a reentrant curve—the *pallial sinus*—indicating that the animal had a retractile siphon. The various parts described are indicated in fig. 134.

The principal soft parts of the animal comprise: the *mantle*, consisting of two fleshy folds, one lining each valve, and building it; the *abdomen*, with the anteriorly placed *mouth*, and the antero-ventral *foot;* the *gills*, or *branchiae*, which consist of complicated lamellae hanging on either side of the abdomen in the mantle cavity; and the *siphons*—present only in certain forms—posteriorly placed, often capable of great extension, and serving, the one for the entrance of the water and food particles, and the other for the exit of the water and waste products.

Genus PTERINEA Goldfuss

[Ety.: *πτερόν*, wing]

(1826. *Petrefacta Germaniae*, p. 133)

Shell inequivalve, inequilateral; posterior side winged, anterior end nasute or with a well defined ear. Ligament internal; ligamental area longitudinally striated. Cardinal teeth two or more; lateral teeth linear oblique. Posterior muscular impression large, situated on the post-umbonal slope; anterior muscular impression small, situated within the rostral cavity. Test ornamented with rays.

Pterinea emacerata (Conrad) (Fig. 135). Avicula emacerata Conrad (Hall. 1852. *Pal. N. Y.* 2:228, pl. 59)

Distinguishing characters. Moderately oblique; large and posteriorly concave wing often extending beyond the shell below; small anterior ear; flat, smooth right valve with striated wing; convex left valve, with strong radii, interrupted by fainter concentric striae.

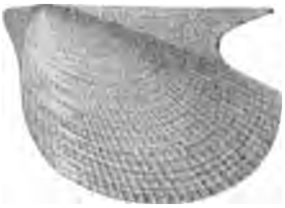


Fig. 135 Pterinea emacerata

Found perhaps in the Clinton shale, rarely in the lower and middle Rochester shale and abundantly in the upper shale. Niagara sections. Also at Lockport and elsewhere (Hall).

Genus LIOPTERIA Hall

[Ety.: λεῖος, smooth; πτερόν, wing]

(1883. *Pal. N. Y.* v. 5, pt 1, p. 4)

Shell aviculoid, oblique, subrhomboidal; anterior end not auriculate; wing large, extremity produced. Hinge narrow, furnished with a slender lateral tooth just posterior to the beak and nearly parallel to the hinge line. Ligament external; ligamental area narrow, extending the entire length of the hinge, marked by fine, sharp, longitudinal striae. Test with concentric striae but without rays.

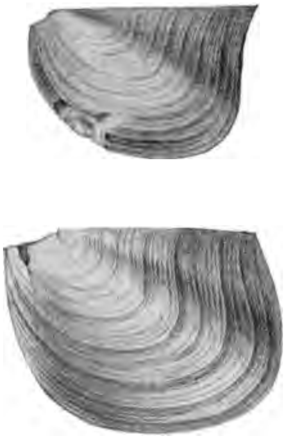


Fig. 136 Liopteria (?) subplana

Liopteria (?) subplana (Hall) (Fig. 136). Avicula subplana Hall (1852. *Pal. N. Y.* 2:283, pl. 59)

Distinguishing characters. Depressed convex surface; similarity of right and left valves; ill defined wing and ear; concentric striae; absence of radii.

Found in the Rochester shale at Lockport associated with Pterinea emacerata, etc. (Hall). Probably also at Niagara. The generic reference is provisional.

Genus LYRIOPECTEN Hall

[Ety.: λύριον, small lyre; *pecten,* comb, i. e. the genus Pecten]

(1884. *Pal. N. Y.* v. 5, pt 1, p. 12)

Shell inequivalve, with a short hinge line and very small anterior ear. Cartilage in shallow furrows, parallel to the hinge margin. Surface ornamented with rays.

Lyriopecten orbiculoides (nom. nov.) cf. Avicula (?) orbiculata Hall (1852. *Pal. N. Y.* 2:284, pl. 59)

Distinguishing characters. Right (?) valve convex; left (?) valve flat; form suborbicular, hinge line short, straight; strong radiating striae cancelated by equally strong concentric striae, forming surface similar to Pterinea emacerata.

Found in a loose block of limestone, probably the lower Lockport limestone, at Niagara. One specimen.

The identification with Hall's species and the generic reference are provisional.

Genus MODIOLOPSIS Hall

[Ety.: Modiolus, a genus of recent shells; ὄψις, appearance (similar to)]

(1847. *Pal. N. Y.* 1:157)

Shells equivalve; valves elongate oval, closed, with nearly terminal beaks and narrow hinge plate, and without teeth; adductor scars subequal; ligament deep-seated.

Modiolopsis orthonota (Conrad) (Fig. 137) (Hall. 1852. *Pal. N. Y.* 2:10, pl. 4 bis)

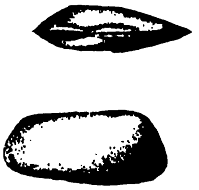


Fig. 137 Modiolopsis orthonota

Distinguishing characters. Subelliptic or rhomboidal form; straight hinge line; obliquely truncated anterior and rounded posterior ends; ventral and dorsal margins nearly parallel; elevated, thin, sharp umbones, with a faint ridge extending to the posterior basal margin; surface with concentric growth lines only.

Found in the upper Medina sandstones at Niagara. Also in the same beds at Lockport, usually as molds.

Modiolopsis primigenia (Conrad) (Fig. 138) (Hall. 1852. *Pal. N. Y.* 2:10, pl. 4 bis)

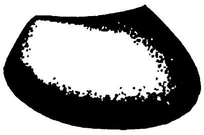


Fig. 138 Modiolopsis primigenia

Distinguishing characters. Subrhomboidal form; rounded anterior and expanded alate posterior ends; straight hinge line, produced posteriorly; rounded ventral margin; fine radiating striae visible only in well preserved shells; strong concentric growth lines.

Found usually as internal molds, in the upper Medina sandstones of the Niagara sections, and at Lockport and elsewhere.

Modiolopsis sp. (Compare M. subalatus. *Pal. N. Y.* 2:84, pl. 27, fig. 5, 6; p. 285, pl. 59, fig. 7)

Distinguishing characters. A small left valve, strongly convex below the umbo; a strong cardinal ridge extends from beak to posterior basal margin, and above this the surface of the posterior wing is slightly concave; beaks incurved, hardly raised above the hinge line; posterior end more sharply rounded than anterior; surface with concentric striae.

Found in the Clinton lenses on the Rome, Watertown and Ogdensburg railroad.

Class GASTROPODA Cuvier

The gastropods, or snails, are mollusks with a distinct head, a muscular foot, and a mantle consisting of a single lobe. They are terrestrial, marine, or fresh-water animals, and are commonly protected by a conic or spirally coiled shell, which is secreted by the mantle. The apical part of the shell usually consists of a simple coiled embryonic shell, or *protoconch*. Succeeding this is the shell proper, which, when coiled comprises few or many *whorls*, the later overlapping the earlier ones to a greater or less extent. The *suture* at the junction of the overlapping whorls may be faintly or strongly impressed. The whorls may coil closely, forming a compact central *columella*; or they may be loosely coiled, leaving a hollow columella, opening below in the *umbilicus*. The body whorl opens in the aperture, the rim or *peristome* of which consists of an *outer* and an *inner*, or *columellar lip*. The peristome is *complete* when both inner and outer lip are present, and *incomplete* when the place of the inner lip is taken by the preceding whorl. In a great many species the peristome is notched anteriorly, or produced into a straight, or more or less flexed canal. A posterior notch is also frequently found. The columellar lip and, in its absence, the columella, may be smooth or furnished with one or more plications. Similarly, the outer lip may be smooth on its inner side or furnished with plications or *lirae*. Among the external features of importance are the transverse *lines of* growth, which mark the successive increments; *varices* or rows of spines, parallel to the lines of growth, and marking periodic resting stages during the growth of the shell; and revolving longitudinal lines or ridges, which may be uniform or alternating, or may show a gradation in size. When transverse and longitudinal lines cross each other, a reticulated surface ornamentation is produced; and, when the shell is covered by an epidermis, or *periostracum*, hair-like spines not infrequently arise from the points of crossing. In Pleurotomaria and related gastropods, a siphonal notch occurs in the outer lip, and its progressive closure from behind leaves a marked revolving band, commonly visible only on the body whorl.

Many species, specially of marine gastropods, secrete a horny or calcareous *operculum*, which is attached to the foot, and closes the aperture of the shell when the animal is withdrawn. This is seldom preserved in a fossil state.

Genus PLATYCERAS Conrad

[Ety.: *πλατύς*, flat; *κέρας*, horn]

(1840. *An. rep't pal. N. Y.* p. 205)

Shell conic, irregular, with or without the apex inrolled; aperture expanded, often reflexed; peristome entire, often sinuous; surface variously striated, sometimes bearing spines.

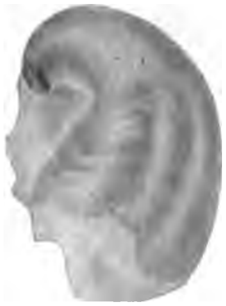


Fig. 139 Platyceras niagarense

Platyceras niagarense (Hall) (Fig. 139). Acroculia niagarensis Hall (1852. *Pal. N. Y.* 2:288, pl. 60)

Distinguishing characters. Involute apex, scarcely forming a volution; gradually expanding lower portion, with two or three longitudinal folds or undulations; transverse striae, which undulate across the folds and depressions.

Found rarely in the lower Rochester shale at Niagara. Also at Lockport (Hall).

Platyceras angulatum (Hall) (Fig. 140). Acroculia angulata Hall (1852. *Pal. N. Y.* 2:289, pl. 60)

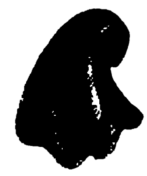


Fig. 140 Platyceras angulatum

Distinguishing characters. Attenuated apex, forming one or two minute volutions; shell below extending in a broad curve, and expanding rapidly toward the aperture, which is much dilated; angulated surface, with a sharp carina on the upper and lower outer margins, and an obtuse carina in the middle; transverse section unequally pentagonal.

Found in the lower and middle Rochester shale at Niagara. Rare. Also at Lockport (Hall).

Genus DIAPHOROSTOMA Fischer

[Ety.: *διάφορος*, unlike; *στόμα*, mouth]

(1885. *Manual de Conchyliologie;* Platyostoma Conrad. 1842. *Acad. nat. sci. Jour.* 8:275)

Shell with a short depressed spire, a large dilated aperture and with the inner lip lying close against the body whorl.

Diaphorostoma niagarense Hall (Fig. 141) (1852. *Pal. N. Y.* 2:287, pl. 60)

Distinguishing characters. Globose contour; three to four volutions; large body whorl, inflated toward the dilated aperture; deeply depressed sutures; fine longitudinal and strong transverse striae. Not infrequently a sinuosity is indicated by the lines of growth.

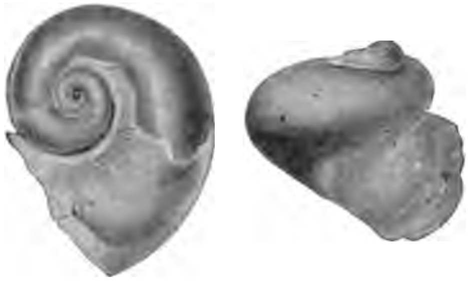


Fig. 141 Diaphorostoma niagarense

Found in the Clinton limestone lenses, and the lower and middle, and rarely the upper Rochester shale at Niagara. Also at Lockport and elsewhere (Hall).

Genus PLEUROTOMARIA De France

[Ety.: *πλευρά*, side; *τομή*, a cut]

(1824. *Tableau d. corps organises fossiles*, p. 114, and *Dict. sci. nat.* 41 :381)

Shell Trochus-shaped, more or less conic, with or without umbilicus; volutions angular, flattened, or rounded, their surfaces variously ornamented; aperture subquadrate to suborbicular, the inner lip thin. The outer lip bears a narrow, deep fissure or sinus, which is the unclosed continuation of a revolving band.

Pleurotomaria littorea Hall (Fig. 142) (1852. *Pal. N. Y.* 2:12, pl. 4 (bis))

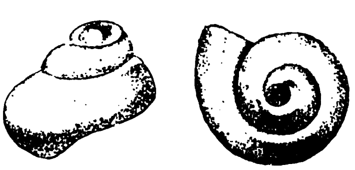


Fig. 142 Pleurotomaria littorea

Distinguishing characters. Medium size; subconical form; three to four somewhat obtusely angular volutions, which enlarge rapidly; small umbilicus.

Found in the upper Medina sandstone at Lockport (Hall). Fragments in the same rock at Niagara seem to be of this species.

Pleurotomaria pervetusta (Conrad) (Fig. 143) (1852. *Pal. N. Y.* 2:12, pl. 4 (bis))

Distinguishing characters. Small size; depressed conic spire, the volutions strongly embracing; whorls about four, gradually enlarging; large umbilicus extending to the apex.

Found in the upper Medina sandstones of the Niagara sections. Also at Lockport (Hall).

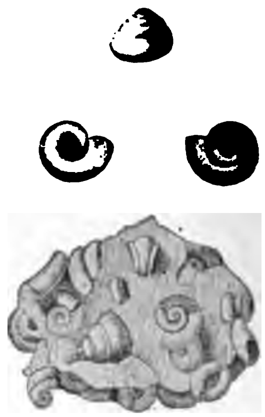


Fig. 143 Pleurotomaria pervetusta

Genus BUCANIA Hall

[Ety.: *bucina*, a trumpet]

(1847. *Pal. N. Y.* 1:32)

Shells coiled, a single plane, with the spire equally concave on either side and all the volutions visible; outer whorl ventricose; all whorls embracing to some extent, having an inner concavity; aperture rounded, oval, somewhat compressed on the inner side from contact with preceding whorl.

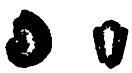


Fig. 144 Bucania trilobata

Bucania trilobata (Conrad) (Fig. 144) (Hall. 1852. *Pal. N. Y.* 2:13, pl. 4 (bis))

Distinguishing characters. Suborbicular form; three-lobed volutions, all of which are visible; last whorl greatly expanded; aperture wider than long.

Found at Medina and Lockport and fragments in the upper Medina of Niagara indicate its presence there.

Class CONULARIDA

Paleozoic mollusks of doubtful systematic position, resembling some modern Pteropoda, but only distantly and ancestrally related to them. Shells conic or tubular, elongate, septate and variously ornamented.

Genus CONULARIA Miller

[Ety.: diminutive of *conus*, a cone]

(1821. Sowerby. *Mineral conchology,* 3:107)

Shell elongated, pyramidal, with the transverse section varying from quadrangular to octagonal; angles indented by longitudinal grooves. The surface is variously ornamented by transverse or reticulated striae. Near the apex the shell is furnished with a transverse septum.

Conularia niagarensis Hall (Fig. 145) (1852. *Pal. N. Y.* 2:294, pl. 65)

Distinguishing characters. Broad, pyramidal, tapering abruptly; deep abrupt channels of the angles; shallow, scarcely defined depression of centers of faces; fine and closely arranged transverse striae, which extend from the angles obliquely to the center, and bend more abruptly in crossing the central depression; granulate character of striae; intermediate spaces with longitudinal striae.

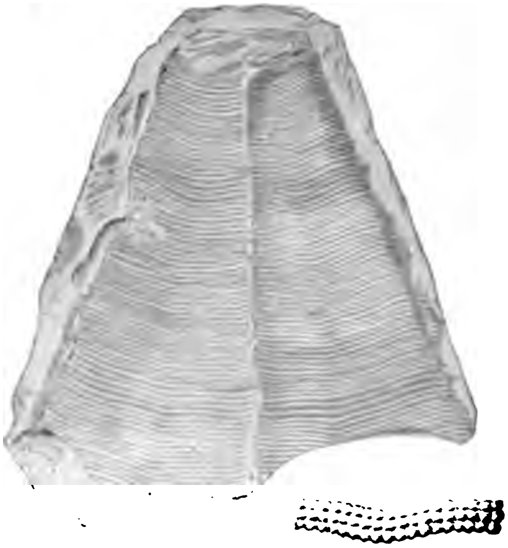


Fig. 145 Conularia niagarensis with several striae enlarged

Found in the Rochester shale at Lockport (Hall). Probably occurs also at Niagara.

Class CEPHALOPODA Cuvier

The cephalopods are the most highly developed mollusks, possessing a distinct, well defined head, a circle of eight or more arms surrounding the mouth and generally furnished with suckers or hooks, a funnel like hyponome, or swimming organ, and a highly developed nervous system. The majority of modern genera are naked, or with only a rudimentary internal shell (squids, cuttlefish, etc.). Nautilus is the only modern genus with a typical external shell.

The shells of cephalopods are chambered, i. e. divided by a series of transverse floors or septa, into air chambers. The last or living *chamber* lodges the animal. The septa are pierced by a corresponding series of holes, the walls of which are often prolonged backward or forward into *siphonal funnels*, the whole constituting the *siphuncle*.

In the Nautiloidea, the sutures are, as a rule, simple or but slightly lobed, and the siphuncle is commonly central or eccentric, but seldom marginal, with the funnels generally directed backward. The embryonic shell, or protoconch, is rarely retained.

The shells of cephalopods are either straight (more or less conic) or variously curved and coiled to close involution.

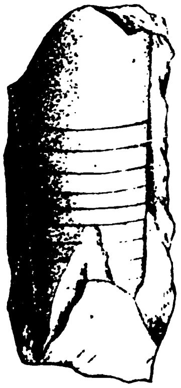


Fig. 146 Orthoceras multiseptum

NAUTILOIDEA

Genus ORTHOCERAS Breyn

[Ety.: *ὀρθός*, straight; *κέρας*, horn]

(1732. *Dissertatio physica de polythalamiis*)

Shell a straight conic tube, with a large body chamber and numerous air chambers, separated by convex septa. Sutures simple, at right angles to the long axis of the shell; siphuncle central, subcentral, or eccentric, cylindric or sometimes widening in the chambers. Surface smooth or variously ornamented by transverse or longitudinal striae, or by annulations.

Orthoceras multiseptum Hall (Fig. 146) (1852. *Pal. N. Y.* 2:14, pl. 4 (bis))

Distinguishing characters. Cylindric, gradually tapering; septa distant one sixth to one seventh the diameter.

Found in the upper Medina sandstone at Lockport, etc. (Hall). Probably also at Niagara.

Orthoceras annulatum Sowerby (Fig. 147). Orthoceras undulatum Hall (1852. *Pal. N. Y.* 2:293, pl. 64, 65)

Distinguishing characters. Strong annulations; moderately strong longitudinal lines which node the annulations, fine transverse striae; elliptic cross-section; subcentral siphuncle.

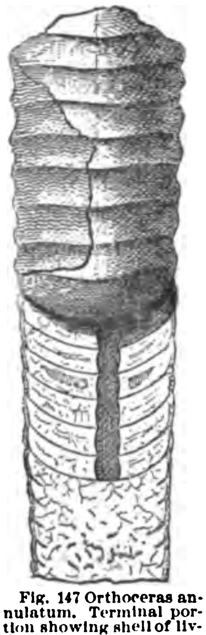


Fig. 147 Orthoceras annulatum. Terminal portion showing shell of living chamber and sectioned camerae (after Barrande)

Found in the Clinton limestone lenses in the Rome, Watertown and Ogdensburg railroad cut above Lewiston. Also in the Rochester shale and Lockport limestone at Lockport (Hall), and probably also at Niagara.

Orthoceras medullare Hall (1860. *Geol. sur. Wis. Rep't prog.* p. 4)

Distinguishing characters. Cylindric, gradually tapering form; septa distant nearly half the diameter; large siphuncle, slightly expanded between septa; strong sharp subequal longitudinal striae, with often alternating finer striae; smooth cast.

Found in the Clinton limestone lenses in the Rome, Watertown and Ogdensburg railroad section above Lewiston. Rare. The species is normally a western one.

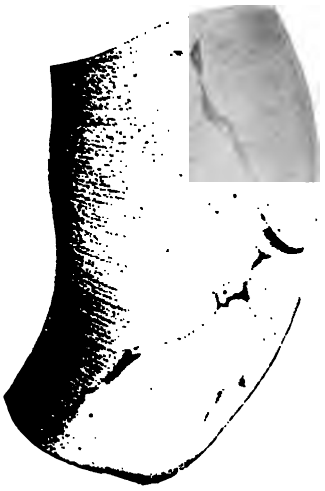


Fig 148 Cyrtoceras subcancellatum

Genus CYRTOCERAS Goldfuss

[Ety.: κυρτός, curved; κέρας, horn]

(1837. *De la Beche, Handb. d. Geogn. bearb. von v. Dechen.* p. 536)

Shell conic and gently curved, with a depressed elliptic to trigonal cross-section, the aperture in old shells contracted to a T-shaped opening; siphuncle large, eccentric.

Cyrtoceras subcancellatum Hall (Fig. 148). Cyrtoceras (?) cancellatum Hall (1852. *Pal. N. Y.* 2:290, pl. 61)

Distinguishing characters. Arcuate; transversely oval section; transversely striated surface, and faint longitudinal striae; siphuncle submarginal.

Found in the " limestone below the cliff at Niagara Falls " (Hall).

Genus GOMPHOCERAS Sowerby

[Ety.: γόμφος, a pin, bolt, or club; κέρας, a horn]

(1839. Murchison. *Silurian system*, p. 620)

Shell straight or curved, pear-shaped, greatest diameter in front of the middle; cross-section circular; mouth contracted, opening by a T-shaped aperture; siphuncle central or eccentric, subcylindric or expanding between the septa (moniliform).

Gomphoceras ? sp. (Hall. 1852. *Pal. N. Y.* 2:290, pl. 61)

Distinguishing characters. Subfusiform aperture narrowed, gradually tapering to the extremity; surface striated transversely.

This fossil has the general form and appearance of Gomphoceras, though I am unable to discover any marks of septa. The greatest expansion appears to be at about one third of the distance from the aperture to the apex.

Found "in a fragment of limestone below the cliff at Niagara Falls" (Hall).

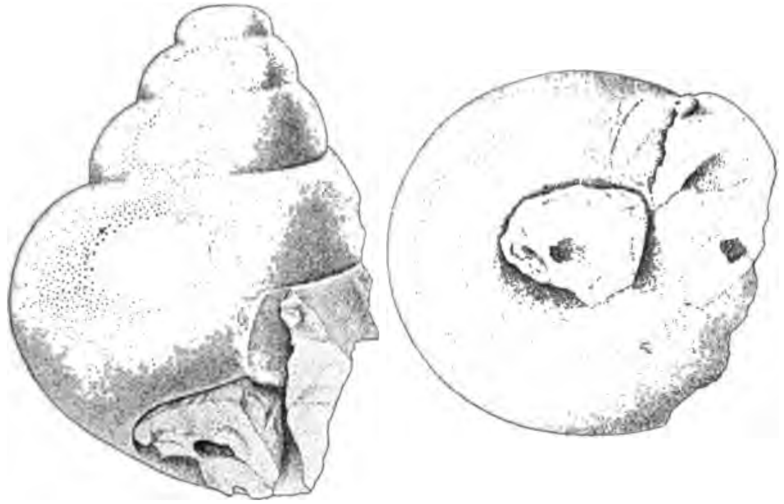


Fig. 149 Trochoceras gebhardi, two thirds natural size

Genus TROCHOCERAS Hall

[Ety.: τροχός, a wheel; κέρας, a horn (named from its trochus or top-like shape)]

(1852. *Pal. N. Y.* 2:335)

Shells turbinate or trochiform; spire elevated as in Gastropoda, more or less ventricose and umbilicated; aperture rounded or round oval; volutions above the outer one with septa; siphuncle submarginal or dorsal.

Trochoceras gebhardi Hall (Fig. 149) (1852. *Pal. N. Y.* 2:335, pl. 77, 77A; Grabau. *Geol. soc. Am. Bul.* 11:371, pl. 21)

Distinguishing characters. Deep and wide umbilicus with angular margins; cross-section of body whorl irregularly subhemispheric;

apical angle of spire about 60°; fine crowded surface striae. In the specimens so far obtained from the Manlius limestone, no septa have been preserved.

Found in the Manlius limestone of North Buffalo (Vogt & Piper, fig. 149) and Williamsville. The species was originally described from the Coralline limestone (Niagara) of Schoharie county (N. Y.)

Class CRUSTACEA Lamarck

Order OSTRACODA Latr.

The ostracods are small crustacea, with a bivalve, calcareous or horny shell covering the entire body. The valves are joined dorsally by a membrane, and open along the ventral side. The body is indistinctly segmented, and bears seven pairs of appendages, two pairs of which represent the trunk limbs. The shell corresponds to the carapace of the higher crustaceans. These organisms are minute and will ordinarily be overlooked unless search is made for them with a lens on the surfaces of the shale laminae. They are specially abundant in the finer grained shales.

Genus ISOCHILINA Jones

[Ety.: *ἴσος*, equal to; *χεῖλος*, lip]

(1858. *Can. organic remains*, Decade 3, p. 197)

Carapace with equal valves, whose margins meet uniformly and do not overlap; greatest convexity central, or toward the anterior end; anterior tubercle present.

Isochilina cylindrica (Hall). Cytherina cylindrica Hall (1852. *Pal. N. Y.* 2:14, pl. 4)

Distinguishing characters. Oval, elongate form; great convexity, "which, when both valves are joined, would give an almost cylindrical form to the shell".

Found in the upper Medina sandstones at Medina (Hall), but probably also at Niagara and other places.

Genus LEPERDITIA Rouault

[Ety.: Leperdit, proper name]

(1851. *Soc. geol. France. Bul.* ser. 2, 8:377)

Carapace with unequal valves, the right valve the larger and overlapping the left valve, along the ventral and, to some extent, along the anterior and posterior ends; valves smooth, oblong and horny.

Leperditia scalaris Jones (Fig. 150) (Grabau. *Geol. soc. Am. Bul.* 11:371, pl. 22)

Distinguishing characters. Bean-shaped outline; straight hinge line with salient angles; uniformly curved basal margin; anterior and posterior marginal borders; ocular tubercle about a third the length of the shell from the anterior end; strong, elongated fold or "dorsal hump" below the hinge line, in the posterior half of the left valve.

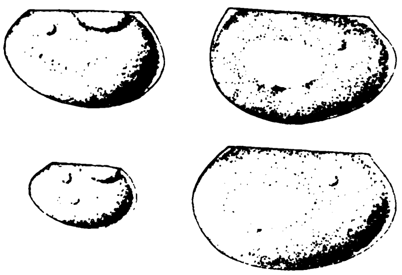


Fig. 150 Leperditia scalaris (enlarged)

Found in the Manlius limestone of North Buffalo and elsewhere in Erie county. It is a common species.

Genus BOLLIA Jones & Holl

[Ety.: Boll, proper name]

(1886. *An. and mag. nat. hist.*, ser. 5, 17:360)

Valves oblong, with rounded and nearly equal ends; hinge line straight, ventral margin curved; surface punctate and bearing a rudely horseshoe-shaped ridge, with a central depression within, and without a semilunar ridge on each side and parallel to the outer margins of the shell, which are slightly rimmed.

Bollia symmetrica (Hall) (Fig. 151). Beyrichia symmetrica Hall. (1852. *Pal. N. Y.* 2:317, pl. 67)

Distinguishing characters. Extremely small size; thin horseshoe ridge, dividing shell into three nearly equal parts; ridges and interspaces about equal; outer ridges not continued ventrally.

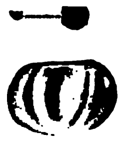


Fig. 151 Bollia symmetrica natural size and enlarged

Found in a fragment of weathered Rochester shale, on the talus along the Rome, Watertown and Ogdensburg railroad cut above Lewiston. Associated with the next. (One specimen found was larger than the normal, and the horseshoe curve rather thick ventrally, but not as thick as in B. lata of the Clinton group. This appears intermediate between the two species.) Also found at Lockport (Hall).

Genus AECHMINA Jones & Holl

[Ety.: *ἀιχμή*, point of a spear]

(*An. and mag. nat. hist.* ser. 4. 3:217)

Carapace with thick valves, straight at hinge line, rounded at the ends, and convex at the ventral border. Surface drawn out into a broad-based and sharp pointed hollow cone, which either involves the whole surface, or rises from the postero-dorsal or centro-dorsal region.

Aechmina spinosa (Hall) (Fig. 152). Cytherina spinosa Hall (1852. *Pal. N. Y.* 2:317, pl. 67)

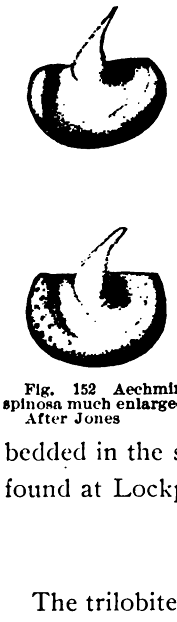


Fig. 152 Aechmina spinosa much enlarged After Jones

Distinguishing characters. Strong oblique spine, thick and hollow at the base, either elongate or short; pointed upward, outward and forward, and sometimes slightly bent; valves thickened on the free border by a raised, rounded but irregular margin; area at base of spine hollow and smooth; raised margin sometimes punctate; spine often long and projecting beyond the upper margin of the valve.

Found in weathered Rochester shale on the talus of the Rome, Watertown and Ogdensburg railroad cut above Lewiston. The valves are often imbedded in the shale with the inner concave surfaces exposed. Also found at Lockport (Hall).

Order TRILOBITA Burmeister

The trilobites are extinct Crustacea, wholly confined to the Paleozoic seas. The body was covered with a carapace longitudinally divisible into three parts. The anterior portion comprises the head-shield, or *cephalon*, which is usually semicircular, with a straight posterior border. The central of the three cephalic lobes is the *glabella*, which is the most prominent part of the cephalon. It is of varying outline, and more or less divided by transverse furrows or pairs of furrows. The last furrow is the *occipital furrow*, and delimits the *occipital ring*, which is just anterior to the first segment of the thorax. On either side of the glabella is a pair of cheeks, divided by the *facial suture* into *fixed cheeks* (those next to the glabella) and *free cheeks* (the outermost portion). The latter are often prolonged into *genal spines.* The compound eyes are situated on the free cheeks, and they are overshadowed by more or less prominent eyelids or *palpebral lobes,* which are lateral lobes from the fixed cheeks. The facial suture thus passes between the eyes and the palpebral lobes, and when, as is often the case, the free cheeks become separated after the death of the animal, only the palpebral lobes remain on the central portion of the cephalon. The border of the cephalon is often distinctly marked, and is spoken of as the *cephalic limb.* At the margin it is folded down and under, making the *doublure,* which, continued backward, often produces hollow or solid genal spines. Near the anterior lower portion of the doublure lies the lower lip, or *hypostoma,* which is usually found separate.

The *thorax* consists of a varying number of segments or rings, articulated with each other, and commonly permitting enrolment. Each consists of a central *annulus* and lateral *pleurae.*

The tail, or *pygidium,* consists of a single piece, comprising a central *axis* and lateral *lobes.* The axis and the lobes commonly show transverse furrows, corresponding to the divisions of the thorax, and they are often so strongly marked that a line of division between thorax and pygidium is difficult to determine.

Great advances have recently been made in our knowledge of the ventral side of trilobites. Probably all of them had jointed appendages, which included antennae, mouth parts and legs, comparable in a general way to those of modern Crustacea.

Genus HOMALONOTUS Koenig

[Ety.: *ὁμᾰλός*, on the same level; *νῶτος*, back]

(1825. *Icones foss. sectiles*, p. 4)

Body usually large, depressed above, with abruptly sloping sides. The axial furrows are indistinct or obsolete. Cephalon depressed convex, wider than long, with rounded genal angles, and somewhat produced anterior margin; glabella almost rectangular, smooth, or with faint lateral furrows. Small eyes situated behind the middle, and converging facial sutures are characteristic. Thorax of 13 deeply grooved segments. Pygidium smaller than the cephalon, elongate triangular, rounded or produced posteriorly; axis with 10 to 14 annulations; lateral lobes smooth or with posteriorly sloping ribs.

Homalonotus delphinocephalus (Green) (Fig. 153) (Hall. 1852. *Pal. N. Y.* 2:309, pl. 68)

Distinguishing characters. Subtriangular cephalon; subquadrate glabella, widening a little posteriorly; small lateral eyes; acute anterior termination of cephalon; non-trilobate character of thorax, narrowing rapidly toward the posterior end; abruptly triangular pygidium ending acutely, faintly trilobate, and strongly ringed both on the axial and lateral portions; granulose surface.

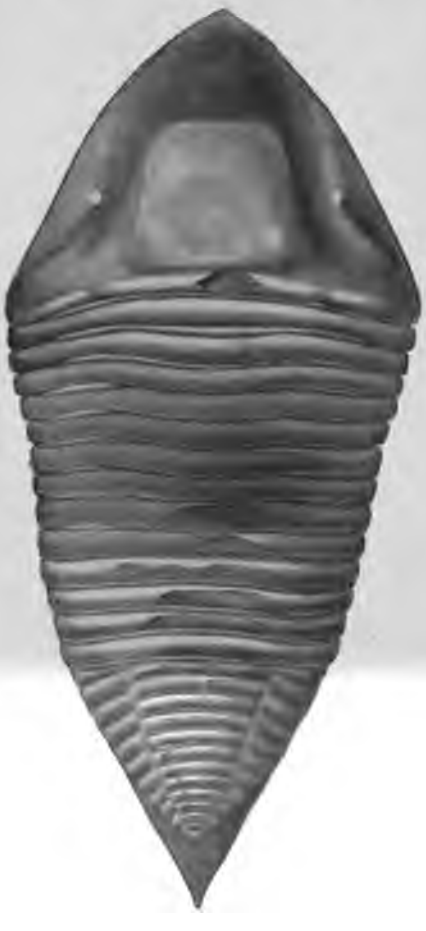


Fig. 153 Homalonotus delphinocephalus, ⅔ natural size

Found rarely in the lower Rochester shale at Niagara, but common in the upper shales. Also found at Lockport and elsewhere (Hall).

Genus ILLAENUS Dalman

[Ety.: *ἰλλαίνω*, to squint]

(1828. *Ueber die Palaeaden*, p. 51)

Cephalon and pygidium of about the same size, large and convex, smooth, semicircular in outline, with the trilobations faintly or not at all marked in either. Glabella smooth, indistinct, eyes large, round, lateral cheeks small. Thorax usually consisting of 10 segments, with smooth pleurae.

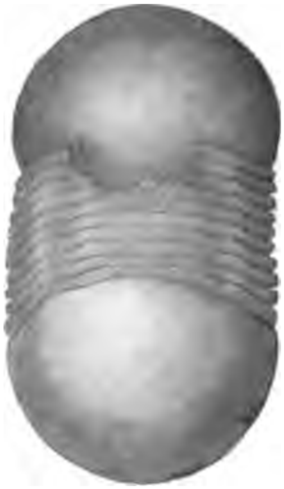


Fig. 154 Illaenus ioxus

Illaenus ioxus Hall (Fig. 154). Bumastis barriensis Hall (1852. *Pal. N. Y.* 2:302, pl. 66)

Distinguishing characters. Elongate elliptic form; rounded, nearly equal cephalon and pygidium, with the trilobation scarcely marked; large eyes near the posterior lateral border of the cephalon; faint trilobation of thorax with very broad central lobe; granulose or punctate surface.

Found in the Clinton limestone lenses in great abundance, usually represented only by cephala and pygidia. These are often crowded together in great profusion to the exclusion of nearly every other fossil. Also found rarely in the lower and middle Rochester shale at Niagara. Also found at Lockport and elsewhere (Hall).

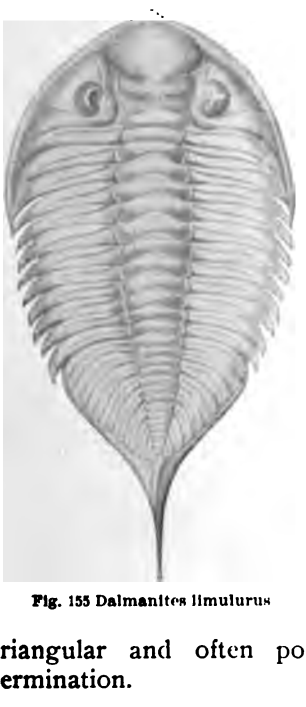


Fig. 155 Dalmanites limulurus

Genus DALMANITES Barrande

[Ety.: proper name]

(1852. *Système silurien Boh.* v. 1)

Cephalon distinctly trilobate, with a large glabella and prolonged lateral or genal spines; glabella tumid, widest in front, and divided by three well marked lateral furrows; facial suture extending from in front of the genal angles inward to the eyes and thence forward around the glabella; eyes large, with numerous distinct lenses. Thorax of 11 segments with grooved pleurae. Pygidium large, of many segments, triangular and often pointed or extended into a mucronate termination.

Dalmanites limulurus (Green) (Fig. 155). Phacops limulurus Hall (1852. *Pal. N. Y.* 2:303, pl. 67)

Distinguishing characters. Sublunate form of cephalon, pointed anteriorly; large slender genal spines; broad anterior and narrow posterior lobes of glabella; pygidium with 15 axial rings, and a long, strong mucronate spine.

Found rarely in the lower and middle but abundantly in the upper Rochester shales at Niagara. Also at Lockport and elsewhere (Hall).

Genus CALYMMENE Brongt.

[Ety.: κεκαλυμμένος, concealed]

(1822. *Hist. nat. corust. foss.* p. 7)

Body oval in outline, readily enrolled; cephalon wider than long; glabella narrowing anteriorly, conic, strongly convex, divided by three pairs of deep glabellar furrows. Facial sutures extending from just in front of the genal angles, converging forward around the eyes and reaching the anterior margin separately. Eyes small; thorax of 13 segments, with deep axial furrows; pygidium from six to 11 segments not distinctly marked off from the thorax.

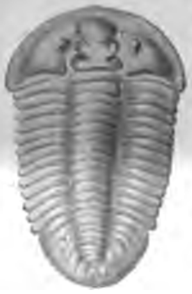


Fig. 156 Calymmene blumenbachi niagarensis

Calymmene blumenbachi niagarensis Hall (Fig. 156) (1852. *Pal. N. Y.* 2:307, pl. 67)

Distinguishing characters. Semicircular outline of cephalon; glabellar lobes tuberculiform; general tapering form of thorax; axis of pygidium with about eight rings; limb grooved nearly to margin, which is thickened and rounded posteriorly.

Found rarely in the Clinton limestone lenses, and the lower Rochester shale at Niagara. Also at Lockport (Hall).

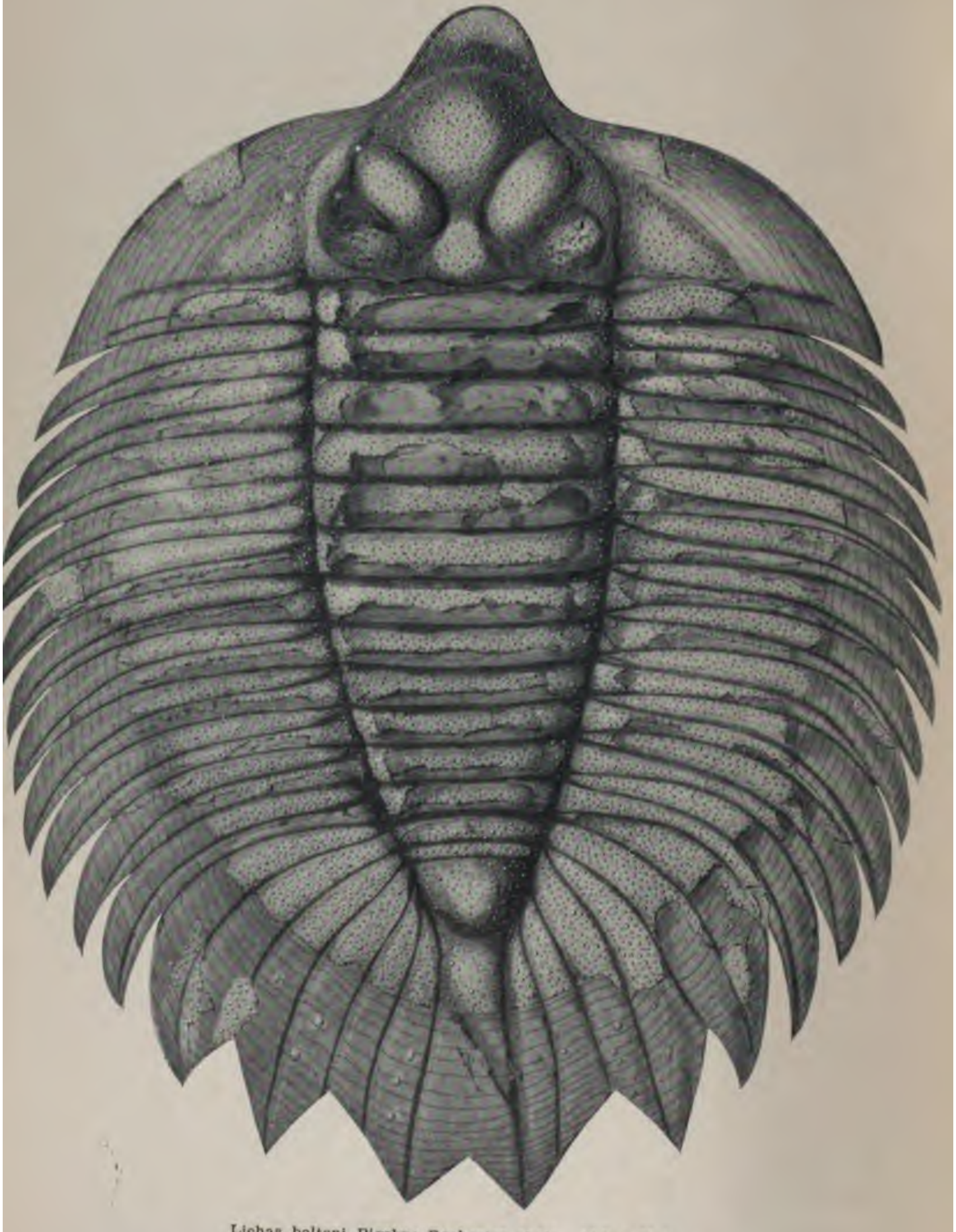
Genus LICHAS Dalman

[Ety.: mythologic name]

(1826. *Ueber die Palaeaden*, p. 71)

Trilobites with large and flat granulated shell. Cephalon small, with spinous genal angles; glabella broad, with a large, tumid anterior lobe, which dominates the smaller reniform lateral lobes on each side; eyes small; facial suture extending from the posterior

Plate 17



Lichas boltoni Bigsby; Rochester shale (After Hall)

OF MICH.

margin obliquely inward to the eyes, and thence almost directly forward, cutting the margin separately. Thorax with nine or 10 segments and grooved and falcate pleurae. Pygidium large and flat, the segments commonly ending in spinous prolongations. Doublure very broad.

Lichas boltoni (Bigsby) (Plate 17) (Hall. 1852. *Pal. N. Y.* 2:311, pl. 69, 70)

Distinguishing characters. Large size; nasute anterior end; large central and oblique lateral lobes of glabella; scabrous surface with backward directed acute pustules; strongly striated doublure; three broad lateral lobes of pygidium, contracting to angular terminations.

Found in the lower Rochester shale at Niagara. Rare and in fragments. Common at Lockport and elsewhere (Hall).

Genus ENCRINURUS Emmrich

[Ety.: *encrinus;* οὐρά =tail (from the resemblance of the pygidium to a crinoid stem)]

(1845. *Neues Jahrb.* p. 42)

Cephalon narrow, wider than long, tuberculated; glabella pyriform, prominent; free cheeks narrow, separated in front; eyes small, elevated, on conic prominences. Thoracic segments 11. Pygidium triangular, with numerous segments.

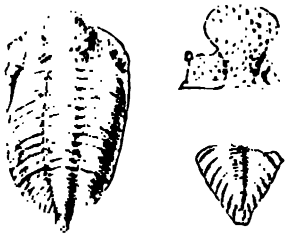


Fig. 157 Encrinurus ornatus

Encrinurus ornatus Hall & Whitfield (Fig. 157). Cybele punctata Hall (1852. *Pal. N. Y.* 2:297, pl. A66)

Distinguishing characters. Strongly pustulose surface of cephalon; pyriform glabella; elongate triangular pygidium, with concavity along the center of the axis, tuberculated at intervals; slender curving ridges of pygidial limb, tuberculated at intervals.

Found in the lower Clinton limestone at Niagara. Rare. Also at Lockport (Hall).

Genus BRONTEUS Goldfuss

[Ety.: mythologic name]

(1839. *Nova act. phys. med. caes. Leop. Carol. Nat. curios.* 19:360)

Dorsal shield broadly elliptic, with the cephalon less than one third the entire length; glabella rapidly expanding in front, with faint lobations. Thorax of 10 segments. Pygidium longer than cephalon or thorax, with a short axis and radiating furrows extending from it across the broad limb. Margin generally entire.

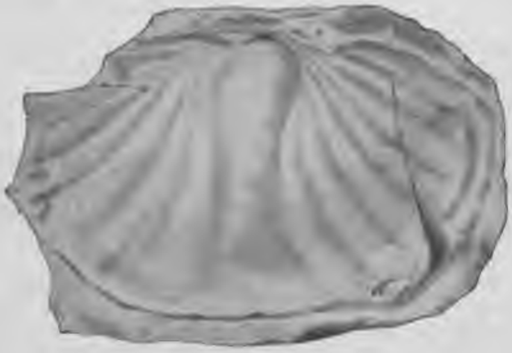


Fig. 158 Bronteus niagarensis; pygidium

Bronteus niagarensis Hall (Fig. 158) (1852. *Pal. N. Y.* 2:314, pl. 70)

Distinguishing characters. Pygidium only known; broad and somewhat semicircular; short axis and from six to nine long curving furrows or sulcations on either side of the center.

Found in "a large fragment of limestone in the Niagara river below the Canada fall" (Hall).

Order PHYLLOCARIDA Packard[1]

Crustacea with the body composed of five cephalic, eight thoracic, and two to eight abdominal segments. Head and thorax covered by a thin chitinous or semicalcareous single or bivalved shell or carapace. A narrow movable plate or *rostrum* lies in front of the caparace. Two pairs of antennae and stalked compound eyes present. Thoracic segments with soft leaf-like legs. Abdomen often ending in spiniform telson, provided with lateral spines.

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[1] This section was revised by Prof. John M. Clarke, who also prepared the synopsis of species and synonymy.

Genus CERATIOCARIS McCoy

[Ety.: κεράτιον, pod; καρίς, shrimp]

(1849. *Ann. mag. nat. hist.* ser. 2, 4:412)

Carapace consisting of a smooth, pod-shaped bivalved shell, without eye nodes. Valves of carapace elongate, subovate, or subquadrate, truncated behind. A free lanceolate rostrum occurs. Body of 14 or more segments, of which from four to seven extend beyond the carapace. Some of these have obscure branchial appendages. Telson a long, pointed spine, with two smaller lateral spines (cercopods) articulated to it.

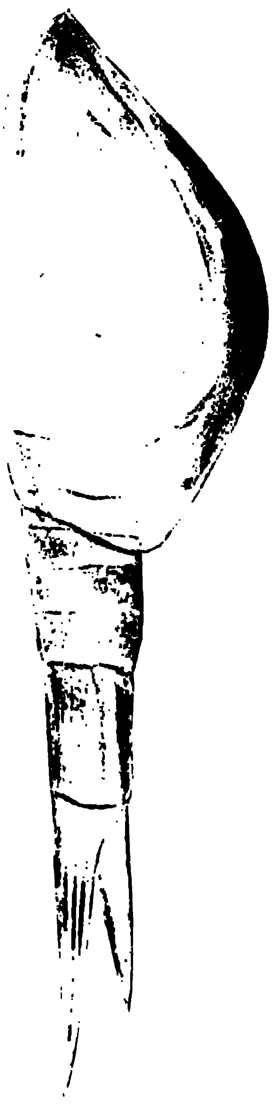


Fig. 159 Ceratiocaris acuminata, Hall

An essentially entire specimen with the various parts in their normal position. The large bivalved carapace is folded along the back and by the breaking away of a portion of the nearer or right side the margin of the other is exposed. Near the anterior extremity are shown a pair of mandibles or "stomach-teeth." The posterior portion of the carapace is seen to inclose several of the abdominal segments and of those which project, the last is very much the longest. Of the caudal spines, three in number, but two are here shown, the long central or telson and one of the lateral or cercopods. Two thirds natural size. From a specimen in the Museum of the Buffalo society of natural sciences.

Ceratiocaris acuminata Hall (Fig. 159) (1859. *Pal. N. Y.* 3:422, pl. 84)

Distinguishing characters. Carapace large, tapering in front, broad medially and rather abruptly truncated on posterior margin. Surface with very fine, raised longitudinal lines. Penultimate segment long; telson and cercopods short.

Found in the Waterlime beds of North Buffalo.

Ceratiocaris (Phasganocaris?) deweyi Hall (Fig. 160) Onchus deweyi Hall (1852. *Pal. N. Y.* 2:320, pl. 71)

Distinguishing characters. Large spine of telson only known; longitudinally grooved; periodic depressions or large pits in the grooves; shown as blunt spines on the rock mold.

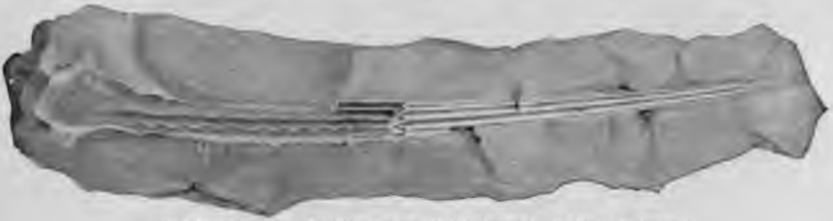


Fig. 160 Ceratiocaris (Phasganocaris ?) deweyi. Telson (reduced)

Found in the Lockport limestone at Niagara; also in the shale at Lockport (Hall).

Order EURYPTERIDA Burmeister

The eurypterids are large Crustacea, with an elongate body composed of cephalothorax, a ringed abdomen, and a tail piece or telson. The body is covered by a chitinous epidermal skeleton, and could be cast off as in the modern horseshoe crab (Limulus). The cephalothorax is usually furnished dorsally with two large, facetted lateral eyes, and a pair of median ocelli; and ventrally with six pairs of legs. The anterior joints or rings of the abdomen bear on their under side five pairs of broad, leaf-like appendages, which are comparable to the gills and operculum of the horseshoe crab. The posterior six segments are without appendages. The legs are comparable to those of Limulus and, like them, their inner margins are furnished with stout spines which serve as teeth. The last pair of legs is generally large, and usually somewhat flattened, and ends in an oval plate. This "paddle" may have been used for swimming purposes or for purposes of anchoring. On the under or ventral surfaces of the first two abdominal segments is the genital operculum, a pair of plates meeting medially, with a median lobe attached which differs in the two sexes.

Genus EURYPTERUS DeKay

[Ety.: *εὐρύς*, broad; *πτερόν*, wing]

(1825. *Lyc. nat. hist. N. Y. An.* 1:375)

Body elongate and narrow, often of great size. Cephalothorax one fifth or one sixth of the whole length, depressed convex, of a subquadrate outline with the anterior angles rounded, and the posterior margin slightly concave; entire margin bordered by a narrow marginal furrow. Eyes reniform, situated somewhat in front of the middle; ocelli close to the axial line. Mouth a ventral cleft. Legs progressively increasing in length backward, the anterior pair with pincers or *chelae;* second, third and fourth pair six to seven-jointed, and covered with fine spines; fifth pair eight-jointed; posterior pair consisting of eight segments, large and powerful, with a large, subquadrate basal joint in each, and a broad terminal " paddle ". Anterior six abdominal segments occupying together about one fourth of the entire body length, short, broad and nearly uniform in shape. Succeeding six segments are ring-like, progressively decreasing in diameter, thus causing a tapering of the body. Telson long and slender.

Eurypterus lacustris Harlan (Hall. 1859. *Pal. N. Y.* 3:407*, pl. 81, 81A, 81B, 83B)

Distinguishing characters. Animal stout; anterior portion of the abdomen very broad, abruptly tapering beyond the sixth segment; penultimate segment quadrate, without lateral flanges.

Very abundant in the Waterlime of North Buffalo.

Eurypterus remipes De Kay (Plate 18) (Hall. 1859. *Pal. N. Y.* 3:404*, pl. 80, 80A, 83B)

Distinguishing characters. Animal small, with lateral body margins making broad outward curves and tapering very gradually backward. Penultimate segment slightly if at all flanged.

Occasionally in the Waterlime of North Buffalo.

Eurypterus pustulosus Hall (1859. *Pal. N. Y.* 3:413*, pl. 83B). Eurypterus giganteus Pohlman (*Buffalo soc. nat. sci. Bul.* 4:41)

Distinguishing characters. Cephalothorax large, short and very broad; eyes on the median transverse line; surface strongly pustulose.

A single specimen has been recorded from the Waterlime of North Buffalo.

Eurypterus robustus Hall, Eurypterus lacustis var. robustus Hall (1859. *Pal. N. Y.* 3:410*, pl. 81C)

Distinguishing characters. Like E. lacustris, but larger and more robust, and proportionately narrower over the anterior abdominal region.

Common in the Waterlime at North Buffalo.

Eurypterus pachychirus Hall (1859. *Pal. N. Y.* 3:412*, pl. 82)

Distinguishing characters. Similar to E. robustus; may prove identical. Terminal joints of the sixth pair of legs very broad.

Rare in the Waterlime at North Buffalo.

Eurypterus dekayi Hall (1859. *Pal. N. Y.* 3:411*, pl. 82)

Distinguishing characters. Proportionally short body; short broad carapace; anterior part of the abdomen very broad, posterior part much contracted. Penultimate segment with elongate lateral flanges.

Occasionally in the Waterlime at North Buffalo.

Genus DOLICHOPTERUS Hall

[Ety.: δολιχός, long; πτερόν, wing]

(1859. *Pal. N. Y.* 3:414*)

Distinguished from Eurypterus by having the sixth pair of cephalothoracic legs long and narrow, with the last two joints of subequal size. Metastoma elongate heart-shaped, as in Pterygotus.

Dolichopterus macrochirus Hall (1859. *Pal. N. Y.* 3:414*, pl. 83, 83A)

Distinguishing characters. Robust, elongated body, long, straight-sided carapace, very anterior eyes; strong and thick jointed anterior appendages; extremely long sixth pair of legs.

Found in the Waterlime beds of North Buffalo.

Genus EUSARCUS Grote & Pitt

[Ety.: εὖ, well; σάρξ, flesh (well-fleshed)]

(1875. *Buffalo soc. nat. sci. Bul.* 3:1)

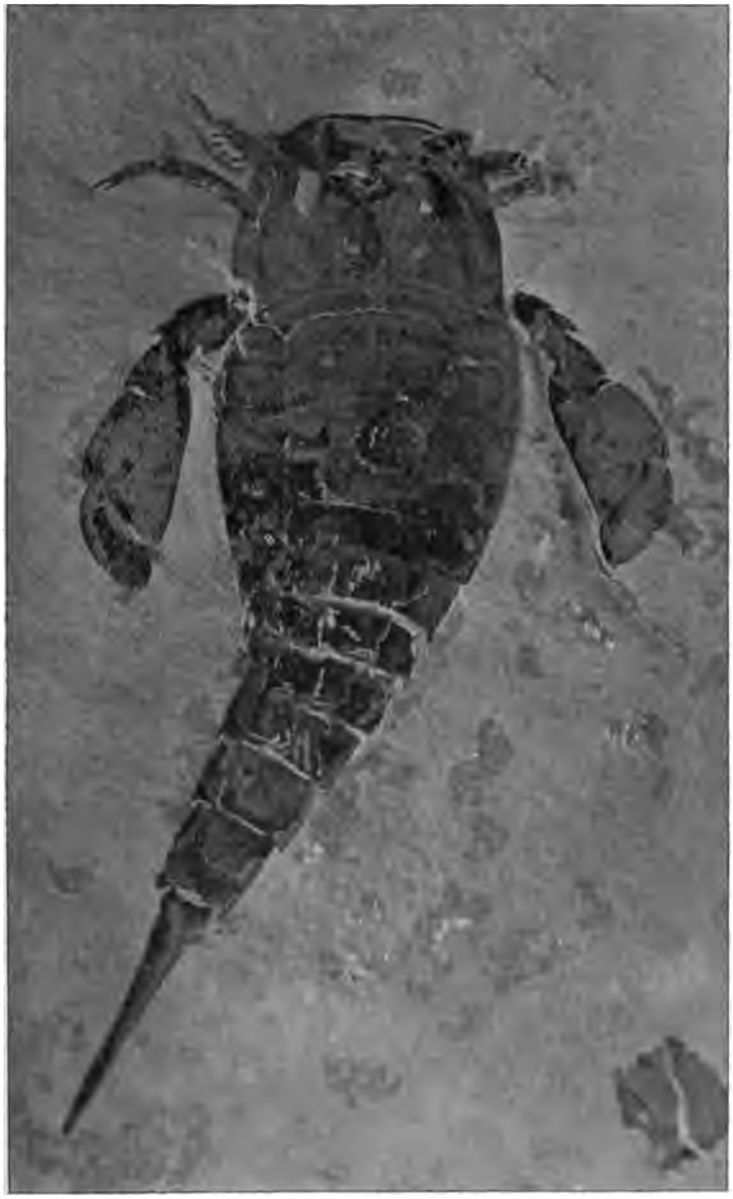
Eurypterids with the anterior six abdominal segments greatly expanded, and the succeeding ones abruptly contracted. The terminal joint of the sixth pair of legs is not expanded.

Eusarcus grandis Grote & Pitt (*Buffalo soc. nat. sci. Bul.* 3:17)

Distinguishing characters. Large size, attaining a length of 2 or 3 feet. Subcylindric posterior abdominal segments.

In the Waterlime at North Buffalo.

Plate 18



Eurypterus remipes DeKay: Rondout Waterlime, Buffalo (original)

Eusarcus scorpionis Grote & Pitt (*Buffalo soc. nat. sci. Bul.* 3:1)

Distinguishing characters. Smaller than the foregoing; average length about 1 foot. Appearance strikingly scorpioid. Telson strongly curved.

In the Waterlime at North Buffalo.

Genus PTERYGOTUS Agassiz

[Ety.: *πτερῦγωτός*, winged]

(1839. Murchison. *Silurian system*, p. 605)

Large, often gigantic eurypterids, with a semiovate cephalothorax, anterior marginal eyes and central ocelli. The first pair of cephalothoracic legs (pre-oral) very long, slender, terminating in large pincers or chelae, and probably prehensile in function. Behind the mouth are four pairs of slender walking legs, and behind these are the large swimming feet, which differ from those of Eurypterus in being less broadly expanded at the ends. Telson an oval plate, either terminating in a short projecting point or bilobed.

Pterygotus macrophthalmus Hall (1859. *Pal. N. Y.* 3:418*). Pterygotus buffaloensis Pohlman (*Buffalo soc. nat. sci. Bul.* 4:17) and Pterygotus acuticaudatus Pohlman (*Buffalo soc. nat. sci. Bul.* 4:42)

Distinguishing characters. Cephalothorax subquadrate or tapering anteriorly; eyes very large and high, with circular base. Chelae (pincers) with angular front end; posterior denticles on larger ramus inclined and serrate.

In the Waterlime at North Buffalo.

Pterygotus cobbi Hall (1859. *Pal. N. Y.* 3:417*, pl. 83B, fig. 4). Pterygotus cummingsi Grote & Pitt (*Buffalo soc. nat. sci. Bul.* 4:18)

Distinguishing characters. Animal large; chelae (pincers) with curved front ends and erect non-serrate denticles.

Rare in the Waterlime at North Buffalo.

Pterygotus globicaudatus Pohlman (*Buffalo soc. nat. sci. Bul.* 4:42)

Distinguishing characters. Animal rather small; surface coarsely tubercled; telson circular without median keel.

A single specimen from the Waterlime of North Buffalo.

DISTRIBUTION OF FOSSILS IN THE SILURIC BEDS

Synopsis of strata:

Medina		1	Upper Medina sandstones and shales
Clinton beds		2	Clinton lower shale
		3	Clinton lower limestone (mainly lowest 4 feet)
		4	Clinton upper limestone (crystalline)
		5	Top beds of Clinton limestone
		6	Clinton lens. Niagara gorge
		7	Clinton lens. R. W. & O. railroad
Rochester shales	Lower shale	8	Lowest foot of shale
		9	Shale 3 feet above Clinton limestone
		10	Shale 4 feet above Clinton limestone
		11	Shale 5 feet above Clinton limestone
		12	Shale 6 to 8 feet above Clinton limestone
		13	Shale 19 feet above Clinton limestone
		14	Shale 25 feet above Clinton limestone
		15	Bryozoa beds
	Upper shale	16	Upper shales
		17	Lockport limestones
		18	Waterlime, Buffalo
		19	Manlius limestone

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Plants																			
Bythotrephis gracilis	....	rc	rc	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
B. lesquereuxi	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	r	....
Arthophycus harlani	[1]c	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Nematophycus crassus	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	r
Hydrozoa																			
Dictyonema retiformis	....	....	....	....	....	....	....	....	....	r	....	r	....	....	....	....	....	....	....
Stromatopora concentrica	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	c	....	....
Anthozoa																			
Enterolasma caliculus	....	....	....	....	r	c	?	rc	....	c	....	....	....	....	r	....	....	....	....
Zaphrentis turbinata	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	?	....	....
Cyathophyllum hydraulicum	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	cc
Chonophyllum niagarense	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Diplophyllum caespitosum	....	....	....	....	....	....	..	....	....	....	....	....	....	....	....	....	....	....	....
Favosites venustus	....	....	....	....	....	....	....	....	....	....	....	....	....	....		....	c	....	....
F. parasiticus	...	....	....	....	....	....	....	....	....	....	....	....	....	....	rc	....	....	....	....
F. pyriformis	....	....	....	....	....	....	....	....	....	....	....	....	....	....		....	....	....	....
F. constrictus	....	....	....	....	....	....	....	....	....	....	....	....	....	....		....	....	....	....
F. niagarensis	....	....	....	....	....	....	....	....	....	....	....	....	....	....		....	c	....	....
Halysites catenulatus			....	....	....	....	....	....	....	....	....	....	....	....		....	rc	....	....
Heliolites elegans			....	....	....	....	....	....	....	....	....	....	....	....		....	....	....	....
H. spinipora			....	....	....	....	....	....	....	....	....	....	....	....		....	....	....	....
H. pyriformis			....	....	....	....	....	....	....	....	....	....	....	....		....	....	....	....
Cladopora seriata			....	....	....	....	....	....	....	....	....	....	....	....	rc	....	....	....	....
C. multipora			....	....	....	....	....	....	....	....	....	....	....	....		....	....	....	....
Striatopora flexuosa			....	....	....	....	....	....	....	....	....	....	....	....	rc	....	....	....	....
Cystoidea																			
Caryocrinus ornatus	....	....	....	....	....	....	....	....	....	c	....	....	r	c	rc	....	....	....	....
Callocystites jewetti	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Crinoidea																			
Stephanocrinus angulatus	....	....	....	....	....	....	....	r	....	c	....	....	....	c	r	....	....	....	....
S. gemmiformis	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....

[1] rr very rare; r rare; rc moderately common; c common; cc very common.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Crinoidea (continued)																			
Thysanocrinus liliiformis																			
Lyriocrinus dactylus														?					
Glyptocrinus plumosus				rc															
Eucalyptocrinus decorus						r						rc		rc	?		rc		
Ichthyocrinus laevis														rc					
Lecanocrinus macropetalus																			
Annelida																			
Cornulites bellistriatus															?				
Bryozoa																			
Diploclema sparsum																			
Ceramopora imbricata																			
C. (?) incrustans																			
Chilotrypa ostiolata														c	rc				
Batostomella granulifera														r					
Lioclema florida															r				
L. aspera																			
Trematopora tuberculosa															c				
T. (?) striata																			
Callopora elegantula															cc				
Phylloporina asperato-striata															c				
Drymotrypa diffusa														r					
Fenestella elegans															rc				
Semicoscinium tenuiceps															rc				
Polypora incepta															c				
Helopora fragilis ?	cc																		
Clathropora frondosa																			
C. alcicornis										r				r					
Rhinopora tuberculosa																			
Diamespora dichotoma															rc				
Lichenalia concentrica			r			c	c			r			r						
Brachiopoda																			
Lingula cuneata	c																		
Pholidops squamiformis														rc					

Dictyonella corallifera	....								....	....				....	....			....	....	....
Leptaena rhomboidalis	....							r	....	....	c	r		rc	c	c				....
Stropheodonta corrugata	....						r		....	....				....	....					....
S. profunda	....			c	rc				....	....				....	....					....
Strophonella striata	....								....	....				....	....		rc			....
S. (?) patenta	....						r		....	....				....	....					....
Plectambonites sericeus	....			r					....	....				....	....					....
P. transversalis	....						rc		r	c	c	rc		r	....					....
Orthothetes subplanus	....			....	....	rc	rc			....			r	?	c	c	rc			....
O. hydraulicus	...			....	....					....				....	....					c
Chonetes cornutus	....	....	....	....	....					....	....			....	....					....
Orthis flabellites	....	....	....	....	....					....	r			....	....					....
O. (?) punctostriata	....	....	....	....	....					....	....			....	....					....
Orthostrophia (?) fasciata	....	....	....	....	....			....	....	....	....		?	....	....	....	....			....
Dalmanella elegantula	....	....	....	....	....		rc	....	....	c	rc			....	r	cc	....			....
Rhipidomella hybrida	....	....	....	....	....			....	....	....	....			....	rc	c	r			....
R. circulus	....	....	....	?	....	....	....	....	....	....	....			....	....	....	....			....
Scenidium pyramidale	....	....	...	....	....	....	....	....	....	....	....			....	....	....	....			....
Anastrophia interplicata	....	....	....	....	....	....	r	....	....	?	....			?	r	rc	....			....
A. brevirostris	....	....	....	....	....	....	....	....	....	....	....			....	....	....	....			....
Pentamerus oblongus	....	....	....	....	rr	....	....	....	....	....	....			....	....	....	...			....
Barrandella fornicata	....	....	....	....	rc	....	....	....	....	....	....			....	....			....	....	....
Rhynchotreta cuneata americana	....	....	....	....	....	....	rc	r	....	....	r			rc	rc	c	r	....	....	....
Camarotoechia obtusiplicata	....	....	....	....	....	....	....	...	....	....	r			. ..	....			....	....	....
C. neglecta	...	....	....	rc	...	....	rc	r	....	....	....			rc	r	c	rc	....	....	....
C. acinus	....	....	....	....	rc	....	....	....	....	....	....			....	....			....	....	....
Rhynchonella robusta	....	....	....	....	....	r	....	....	..	....	....	....		....	....			....	....	....
R. (?) bidens	....	....	....	....	....	....	....	....	....	....	....	....		....	....			....	....	....
R. (?) bidentata	....	....	....	....	....	....	....	....	....	....				....	....			....	....	....
Atrypa reticularis	....	....	....	....	cc	c	rc	r	r	r				....	r	rc		....	....	....
A. nodostriata	....	....	....	....	....	....	c	rc	rc	r	rc			....	rc	cc		....	. ..	....
A. rugosa	....	....	....	....	r	....	rc	?	r	....	rc			....	rc	rc		....	....	....
Cyrtina pyramidalis	....	....	....	....	....	....	....	....	....	....				....	....			....	....	....
Spirifer radiatus	....	....	....	....	rc	rc	c	r	r	....				rc	r	rc		....	....	....
S. niagarensis	....	....	....	....	....	rc	c	....	r	rc		r	c	r	c	c		....	....	....
S. crispus	....	....	....	....	....	....	r	....	....	rc		r		....	c	cc		....	....	....
S. crispus corallinensis	....	....	....	....	rc	....	....	r	....	....	rc			...	....	....	....	....	....	....
S. eriensis	....	....	....	....	....	....	....	....	....	....				....	....	....	....	....	....	rc
S. (Delthyris) sulcatus	....	....	....	....	....	....	r	r	....	....	r		....	....	rc	rc	....	....	....	....

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Brachiopoda (continued)																			
Homoeospira apriniformis	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Trematospira camura	....	....	....	....	....	....	....	....	....	....	....	....	....	....	c	....	....	....	....
Whitfieldella nitida	....	....	....	....	....	cc	rc	....	....	rc	....	rc	r	rc	c	....	....	....	....
W. nitida oblata	....	....	....	....	rr	cc	....	rc	....	c	....	rc	....	c	rc	....	....	....	....
W. oblata	r	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
W. intermedia	....	....	....	....	....	c	....	rc	....	?	....	....	....	....	....	....	....	....	....
W. cylindrica	....	....	....	....	....	....	....	....	....	r	....	....	....	....	....	....	....	....	....
W. sulcata	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	rc
W. rotundata	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	r
W. laevis	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	rc
Hyattella congesta	....	....	r	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Anoplotheca hemispherica	....	c	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
A. plicatula	....	....	cc	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Pelecypoda																			
Pterinea emacerata	....	?	....	....	....	....	....	....	....	....	....	....	....	....	r	c	....	....	....
Liopteria (?) subplana	....	....	....	....	....	....	....	....	....	....	....	r	....	....	....	....	....	....	....
Lyriopecten (?) orbiculoides	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	rr	....	....
Modiolopsis orthonota	c	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
M. primigenia	rc	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Modiolopsis sp	....	....	....	....	....	....	r	....	....	....	....	....	....	....	....	....	....	....	....
Gastropoda																			
Platyceras niagarense	....	....	....	....	....	....	....	....	....	....	....	....	....	....	?	....	....	....	....
P. angulatum	....	....	....	....	....	....	....	....	....	r	....	....	....	r	rc	....	....	....	....
Diaphorostoma niagarense	....	....	....	....	....	r	....	....	....	r	....	r	....	rc	c	r	....	....	....
Pleurotomaria littorea	?	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
P. pervetusta	rc	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Bucania trilobata	?	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Conularida																			
Conularia niagarensis	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....

Cephalopoda																			
Orthoceras multiseptum	?	....				....	.	....	....			....	....		.			....	....
O. annulatum	....	....					rc	....	....			....	....		.		r	....	....
O. medullare	....	....					r	....	....			....	....		.		r	....	....
Cyrtoceras subcancellatum	....	....										....	....		.			....	....
Gomphoceras sp	....	....										....	....		.				r
Trochoceras gebhardi	....	....										....	....		.				....
Ostracoda																			
Isochilina cylindrica	r	....										....	....		.				....
Leperditia scalaris	....	....										....	....		.				c
Bollia symmetrica	....	....										....	....		?				....
Aechmina spinosa	....	....										....	....						....
Trilobita																			
Homalonotus delphinocephalus	....	....			....	....						....	....	r	.	c			....
Illaenus ioxus	....	....			....	c	cc					r	....		r				....
Dalmanites limulurus	....	....			....	....						r	r		r	cc			....
Calymmene blumenbachi niagarensis	....	....			....	r						....	....		r				....
Lichas boltoni	....	....		....	....	....	....					....	....	r	.				....
Encrinurus ornatus	....	....		....	....	....	....	.	....			....	....		.				....
Bronteus niagarensis	....	....	....	....	....	....	....	.	....			....	....		.				....
Phyllocarida																			
Ceratiocaris acuminata	....	....	....	....	....	....	....	.	....			....	....		.			rc	....
C. deweyi	....	....	....	....	....	....		.	....	....		....	....		.		r		....
Eurypterida																			
Eurypterus lacustris	....	....	....	....	....	....		.	....	....	....	....	....		.			cc	....
E. remipes	....	....	....	....	....	....				..	....	....	....		.			rc	....
E. pustulosus	....	....	....	....	....	....				..	....	....	....		.			rr	....
E. robustus	....	....	....	....	....	....					....	....	....		.			c	....
E. pachychirus	....	....	....	....	....	....						....	....		.			r	....
E. dekayi	....	....	....	....	....	....	....								.			rc	....
Dolichopterus macrochirus	....	....		....	....	....	....								.			rc	....
Eusarcus grandis	....	....		....	....	....	....								.			rc	....
E. scorpionis	....	....		....	....	....	....								....	....		rc	....
Pterygotus macrophthalmus	....	....		....	....	....	....								....	....		rc	....
P. cobbi	....	....		....	....	....	....								....	....	....	r	....
P. globicaudatus	....	....		....	....	....	....								....	....	....	rr	....

Chapter 5

POST-PLIOCENE FOSSILS OF THE NIAGARA RIVER GRAVELS

BY ELIZABETH J. LETSON[1] DIRECTOR OF THE MUSEUM OF THE BUFFALO SOCIETY OF NATURAL SCIENCES

The post-Pliocene shells in the gravel beds of the Niagara river have long been known, but never before been fully described. The localities at which shell-bearing gravels have thus far been found are Goat island, Prospect park, Queen Victoria park, Muddy creek, whirlpool (both sides of the river), and at Foster's flats. The shells occur, generally, intimately mixed with the sand and gravel, showing that they were transported to the present localities by currents and eddies. The same action, taking place in recent times, may be witnessed at the lower end of Goat island, where the dividing water washes the shells into the pockets and crevasses in the rock.[2]

The following table shows the distribution of these shells in the various deposits, and also where these forms may be found living today.

NAME OF SPECIES	Goat island	Prospect park	Queen Victoria park	Muddy creek	Whirlpool, American side	Whirlpool, Canadian side	Foster's flats	Living in Niagara river	Living elsewhere
Gastropoda									
1 Pleurocera subulare Lea	x	....	......	....	......	......	....	x	....
2 Goniobasis livescens (Menke)	x	x	x	x	x	x	....	x	....
3 G. livescens niagarensis (Lea)	x	....	......	....	......	......	....	x	....
4 G. haldemani Tryon	x	....	......	....	......	......	....	......	*c*
5 Amnicola limosa (Say)	x	....	......	....	......	......	x	......	....
6 A. letsoni Walker	x	....	......	....	......	......	....	......	....
7 Bythinella obtusa (Lea)	x	....	......	....	......	......	....	......	*b*
8 Pomatiopsis lapidaria (Say)	....	....	......	....	......	x	x	x	....
9 Valvata tricarinata Say	x	....	......	....	......	......	x	x	....
10 V. sincera Say	x	....	......	....	......	......	....	......	*a*
11 Campeloma decisa Say	x	....	......	....	......	......	x	......	....
12 Limnaea columella Say	x	....	......	....	......	......	....	......	*a*
13 L. desidiosa Say	x	....	......	....	......	x	x	......	....
14 L. catascopium Say	x	....	......	....	......	x	x	......	....
15 Physa heterostropha Say	x	....	......	....	......	x	x	......	....
16 Planorbis bicarinatus Say	x	....	......	....	......	......	x	......	....
17 P. parvus Say	x	....	......	....	......	......	x	......	....

a Lime lake.
b Chippewa creek.
c Living, but not within a radius of 50 miles.

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[1] I wish to acknowledge here my obligations to Prof. Henry A. Pilsbry, Mr Bryant Walker and Dr V. Sterki, for valuable assistance and advice given in the preparation of this chapter.

[2] *See also* Chapter 2, Goat island gravels.

NAME OF SPECIES	Goat island	Prospect park	Queen Victoria park	Muddy creek	Whirlpool, American side	Whirlpool, Canadian side	Foster's flats	Living in Niagara river	Living elsewhere
Pelecypoda									
18 Sphaerium striatinum (Lam.)	x	x	x	....	x	......	x	x	....
19 S. stamineum (Conrad).....	x	x	......	....	......	x	....	x	....
20 Pisidium virginicum Bourg..	x	....	......	....	......	......	....	......	*b*
21 P. compressum Prime	x	....	......	....	......	......	....	......	*b*
22 P. abditum Haldeman......	x	....	......	....	......	......	....	......	*a*
23 P. ultra-montanum Prime...	x	....	......	....	......	......	....	......	*a*
24 P. scutellatum Sterki........	x	....	......	....	......	......	....	......	*a*
25 Lampsilis rectus (Lam.)....	x	....	......	....	......	......	....	x	....
26 L. ellipsiformis (Conrad)...	....	x	......	....	......	......	....	x	....
27 Alasmidonta calceola (Lea).	x	....	......	....	......	......	....	x	....
28 A. truncata (Wright)......	x	....	......	....	......	......	....	x	....
29 Unio gibbosus Barnes......	x	x	x	x	......	x	x	x	....
30 Quadrula solida (Lea)......	....	x	......	....	......	......	....	x	....
31 Q. coccinea (Conrad).......	x	x	x	x	......	x	x	x	....

a Lime lake.
b Chippewa creek.
c Living, but not within a radius of 50 miles.

Class GASTROPODA Cuvier

Genus PLEUROCERA Rafinesque. 1819

Shell lengthened and conical, aperture moderately prolonged into a short spout or canal in front. The columella is not thickened.

Pleurocera subulare Lea (Fig. 161) (*Philos. soc. Trans.* 4:100)

Shell large and heavy, elevated and turreted, having an acute apex; nine to 11 whorls, flat, shouldered at the suture, which is impressed; body whorl surrounded by three ridges, the middle being the most prominent; aperture small, lip thin, folding back over the columella and covering the umbilical tract.

Locality. Goat island.

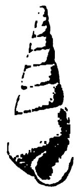

Fig. 161 Pleurocera subulare

Genus GONIOBASIS Lea. 1862

Shell heavy, elongated or ovate, aperture plain, slightly angulated in front.

Goniobasis livescens (Menke) Tyron 1873 (Fig. 162). Melania livescens Menke (1830. *Syn. meth.* p. 135)

Goniobasis livescens Tryon (1873. *Smith. Misc. coll. no.* 253, p. 248)

Shell oblong and ovate; six or seven whorls; early volutions slightly keeled; spire acute; sutures impressed; whorls convex and crossed by plainly marked growth lines; lip moderately thin, and thin callous on the columella.

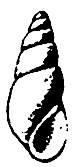

Fig. 162 Goniobasis livescens

This is the most common of all the shells occurring in these deposits along the Niagara river; it is subject to great variation.

Localities. Goat island, Prospect park, Whirlpool, etc.

Goniobasis livescens var. **niagarensis** (Lea) Tryon 1873 (Fig. 163). Melania niagarensis Lea (1841. *Philos. soc. Phil. Proc.* 2:12). Goniobasis livescens var. niagarensis Tryon (*Smith. Misc. coll.* no. 253, p. 248)

Shell conic, obtuse, thick and smooth; spire short, whorls five or six, surrounded by a sharp keel, which clearly marks the suture; aperture elliptic; lip thin; columella slightly calloused.

Prof. H. A. Pilsbry, who examined these shells, writes: "This remarkable form differs from G. livescens, and var. niagarensis, in the persistence of the peripheral keel to the adult stage, producing a shell contour similar to Anculosa carinata; it has not hitherto been described or noticed in conchological literature, and would be entitled to specific rank were it not connected by intermediate forms with var. niagarensis".

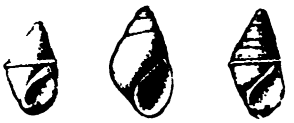

Fig. 163 Goniobasis livescens var. niagarensis

Locality. Goat island.

Goniobasis haldemani Tryon 1865 (Fig. 164). G. haldemani Tryon. (1865. *Am. jour. conch.* 1:38)

Shell elongated, narrow and rather thin; eight or nine whorls, which are flat, smooth and separated by a slightly impressed suture; aperture small, subrhomboidal; lip thin, moderately incurved on the columellar side.

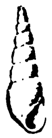

Fig. 164 Goniobasis haldemani

This graceful shell is very scarce and is not represented in the recent fauna.

Locality. Goat island.

Genus AMNICOLA Gould & Haldeman. 1841

Shell small, short, subglobular, and ovate; spire obtuse; shell smooth, thin and perforate; aperture ovate; lip thin; operculum corneous.

Amnicola limosa (Say) Hald. 1844. Paludina limosa Say (1817. *Acad. nat. sci. Phil. Jour.* 1:125). Amnicola limosa Haldeman (1844. *Monograph* pl. 1, fig. 5, 6)

Shell small and conic; whorls four, rapidly diminishing; apex acute, suture deep; umbilicus narrow and deep; surface smooth; recent specimens show growth lines; aperture oval, slightly angulated at the junction of the body whorl; lip simple.

Found in the gravel pit on Goat island.

Amnicola letsoni Walker 1901 (Fig. 165)

A. letsoni Walker (Feb. 1901. *Nautilus*)

Shell small, elevated and thick; whorls four or five, more or less flattened, and inclined to be shouldered; suture deep; spire short, less than one third the entire length; apex obtuse; aperture small and oval, angled above, rounded below, flattened on the parietal margin; lip thick and free from contact with the body whorl.

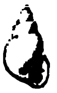

Fig. 165 Amnicola letsoni x3

Locality. Goat island.

In his notes Mr Walker says: "Amnicola sheldoni Pils. is the only species with which this can be compared. The present species is to be distinguished by its flattened, shouldered whorls, deeper suture and more acuminate spire. Six mature examples were found, which, though differing somewhat in the relative proportions of length and width, are as a whole quite uniform. In four of them the peristome is distinctly separated from the body whorl; in one, while continuous, it is so close as to be almost adnate, while in the remaining specimens the parietal margin, although somewhat broken, seems to have been appressed to the body whorl for a short distance. Associated with these specimens were two other examples quite similar, but much more cylindrical in the outline, less solid, and with the aperture less angled posteriorly. Neither is quite mature, judging from the thinness of the lip. In view of the considerable variation in these particulars in other well-known species of the genus, such as Amnicola lustrica Pils., and of the few specimens now at hand, it is not deemed advisable at the present time to do more than call attention to the fact."

What may prove to be other species of Amnicola has been found, but too badly worn to justify description.

Genus BYTHINELLA Moquin-Tandon. 1855

Shell elongated and pyriform; imperforate; apex obtuse; aperture oval; lip simple; operculum corneous.

Bythinella obtusa (Lea) Binney 1865 (Fig. 166). Paludina obtusa Lea (1844. *Philos. soc. Phil. Trans.* 9:13). Bythinella obtusa Binney (1865. *Smith. Misc. coll.* no. 144, p. 70)

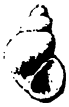

Fig. 166 Bythinella obtusa. x3

Shell small, subcylindric, comparatively thin; five whorls; spire very short, giving the shell a truncated appearance; apex obtuse; sutures well defined; delicate growth lines may be seen with a lens; the aperture is small and round; the umbilicus narrow and deep.

Found in the Goat island gravel pits.

Genus POMATIOPSIS Tryon. 1862

Animal with a broad, short foot, and short pointed tentacles. Shell thin and smooth, having a produced spire; aperture oval, and provided with an operculum.

Pomatiopsis lapidaria (Say) Tryon 1862 (Fig. 167). Cyclostoma lapidaria Say (1817. *Acad. nat. sci. Phil. Jour.* 1:13). Pomatiopsis lapidaria Tryon (1862. *Acad. nat. sci. Phil. Proc.* p. 452)

Shell conic; spire high, seven whorls, well rounded and transversely wrinkled; sutures impressed; aperture rounded and about one third the length of the shell; subumbilicate.

Found at Foster's flats. This species is not found in any of the other deposits.

The locality at Foster's flats, where this little shell is found, is just below the old fall. At the present time, the only locality for P. lapidaria thus far discovered along the river is on the rocks in the constant rain of spray, below the present fall.

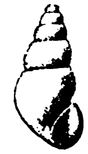

Fig. 167 Pomatiopsis lapidaria. x3

Genus VALVATA Müller. 1842

Animal with a bilobed foot, simple mantle and feather-like gills, protected by a long, slender respiratory lobe. The shell is discoidal, has a deep umbilicus and is provided with an operculum.

Valvata tricarinata Say 1822 (Fig. 168). Cyclostoma tricarinata Say (1817. *Acad. nat. sci. Phil. Jour.* 1:13). Valvata tricarinata Say (1822. *Acad. nat. sci. Phil. Jour.* 2:173)

Shell with four whorls, bearing three prominent carinae; growth lines low and indistinct; suture well impressed; umbilicus large and deep, showing the whorls to the apex; revolving lines or carinae placed one on the upper edge, one on the lower edge, and one on the base.

Found in Goat island gravel pits. As a recent shell, it is very common in the river and its tributary streams.

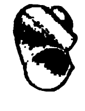

Fig. 168 Valvata tricarinata. x3

Valvata sincera Say (Fig. 175). Valvata sincera Say (*Long's expedition*, p. 264, pl. 15, fig. 11)

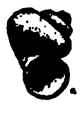

Fig. 169 Valvata sincera. x3

This shell is more globose than the foregoing and has four whorls, rounded and finely wrinkled; aperture round, not diminishing in thickness at the point of contact; umbilicus large, exhibiting the whorls to the apex.

Found associated with V. tricarinata in the gravel on Goat island.

V. sincera is not found in Niagara river at the present time, nor is it found in the immediate vicinity. Lime lake is the only locality within a radius of 50 miles known to the writer for this species.

Genus CAMPELOMA Rafinesque

Animal with a large foot; head of moderate size, situated somewhat back from the end of the foot. Shell thick and solid, oval; spire somewhat produced; surface smooth and rounded; lip simple and continuous; columellar side entirely covers the umbilicus.

Campeloma decisa Say 1817 (Fig. 170). Limnaea decisa Say (1817. *Nich. enc. Am. ed.* 1)

Shell imperforate or nearly so, oval with a smooth surface; whorls five, rounded, last whorl slightly shouldered at the suture; aperture oval; lip simple with a callus on the columellar side.

Locality. Goat island gravel pit.

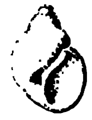

Fig. 170 Campeloma decisa

Genus LIMNAEA Lamarck. 1798

Animal provided with a broad head and flattened triangular tentacles; mantle thickened in front; foot broad and flat. Shell dextral, spire oblong; aperture large and wide; the outer lip is simple, the inner has a fold on the columella.

This genus is well represented among the recent shells in this vicinity. They may be found in all the streams tributary to the Niagara.

Limnaea columella Say 1817 (Fig. 171). L. columella Say (1817. *Acad. nat. sci. Phil. Jour.* 1:14)

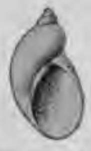

Fig. 171 Limnaea columella

This is a very thin, fragile shell having four whorls, rapidly diminishing, separated by a distinct but not deeply impressed suture; aperture large, more than one half the length of the shell; lip simple, and surface longitudinally wrinkled by growth lines.

Locality. Goat island gravel pits.

Only one specimen of this species was found, leading me to believe that it was an uncommon shell in early post-Pliocene times, as it is at the present time, Lime lake being the only locality in this vicinity where the recent shell occurs.

Limnaea desidiosa Say 1821 (Fig. 172). L. desidiosa Say (1821. *Acad. nat. sci. Phil. Jour.* 2:169)

Shell oblong and subconic, with five very convex whorls; suture deeply impressed; last whorl slightly swollen; slight growth lines visible with a lens.

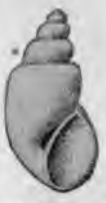

Fig. 172 Limnaea desidiosa x3

Localities. Goat island, Whirlpool and Foster's flats.

This is the most common Limnaea found in these deposits.

Limnaea catascopium Say 1817 (Fig. 173). L. catascopium Say (1817-19. *Nich. enc. Am. ed.* p. 11, fig. 3. 1834. *Am. conch.* v 6. pl. v, fig. 2; 1841. Haldeman. *Monograph* 6, pl. 1)

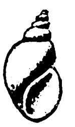

Fig. 173 Limnaea catascopium

Shell thin, sculptured spirally by delicate lines, giving it a very beautiful appearance under the lens; growth lines heavy at the suture, making slight plications; whorls four or five, decreasing to an acute apex; aperture about three quarters the length of the shell; lip simple, folding back on the columellar side and leaving a narrow umbilicus.

Localities. Goat island, Whirlpool and Foster's flats.

Genus PHYSA Draparnaud

The animal of Physa is triangular in general shape; tentacles slender and setaceous; mantle covers part of the shell, the margin folding over the body whorl in a fringe. The shell is sinistral, thin, with an acute spire; body whorl large, inflated and the aperture large and oval; lip simple.

Physa heterostropha Say 1821 (Fig. 174). Limnaea heterostropha Say (1817-19. *Nich. enc. Am. ed.* pl. 1, fig. 6). Physa heterostropha Say (1821. *Acad. nat. sci. Phil. Jour.* 2:172)

Shell oval and smooth, sinistral; whorls four, the first large, the others very small and terminating in an acute apex; aperture large and oval, about half the length of the shell; outer lip a little thickened, inner lip folded back on the columella, forming a slight callus.

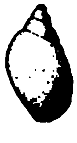
Fig 174 Physa heterostropha. x3

Localities. Goat island, Whirlpool and Foster's flats.

Genus PLANORBIS Guettard. 1756

The animal of Planorbis has a broad foot, and long slender tentacles. The shell is dextral and discoidal; the spire depressed, and the whorls numerous and visible on both sides; the aperture is transversely oval, with a thin lip.

Planorbis bicarinatus Say 1817 (Fig. 175). Planorbis bicarinatus Say (1817-19. *Nich. enc. Am. ed.* pl. 1, fig. 4)

Shell sinistral; sharply carinated on both sides; all the whorls may be seen from either side; aperture vaulted above, angulated below; surface wrinkled with growth lines at regular distances and surrounded by fine revolving striae.

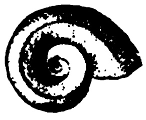
Fig. 175 Planorbis bicarinatus. x2

Locality. Found only in the gravel on Goat island.

Planorbis parvus Say 1817 (Fig. 176). P. parvus Say (1817-19. *Nich. enc. Am. ed.* pl. 1, fig. 5). P. parvus Say (1865. *Smith. Misc. coll.* no. 144, p. 133)

Shell small, with four whorls crossed by wrinkles or growth lines; concave above and below; body whorl slightly swollen; mouth oblique, with the lip simple.

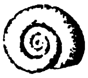
Fig. 176 Planorbis parvus. x2

Locality. Goat island and Foster's flats.

Class PELECYPODA Goldfuss

Genus SPHAERIUM Scopoli. 1777

General shape of the animal oval, margins plain, united behind and ending in two short siphons, which are joined at their base; mouth oval and small; gills broad and unequal, the inner ones largest; the foot tongue-shaped, triangular, flattened and very extensible. Shell thin, oval, often inflated, with prominent beaks;

hinge margin narrow, cardinal teeth very small or rudimentary, one of them more or less bifurcated, one cardinal tooth in the right and two oblique ones in the left valve; lateral teeth compressed and lamelliform, the anterior shortest; ligament short; margins plain; muscular impressions scarcely apparent and pallial line simple.

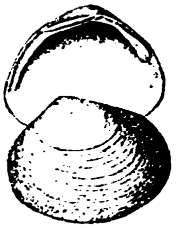

Fig. 177 Sphaerium striatinum. x3

Sphaerium striatinum (Lam.) Prime 1865 (Fig. 177). Cyclas striatina Lamarck (1818. *Animaux sans vertèbres*, 5:560). Sphaerium striatinum Prime (1865. *Smith. Misc. coll.* no. 145, p. 37)

Shell slight, moderately elongated, somewhat compressed, and inequilateral; anterior margin rounded; beaks full, not much raised and not sculptured; sulcations slight and irregular; hinge line curved; cardinal teeth small, double, and of the same size; lateral teeth larger, but not very prominent.

Localities. Found in all the deposits on Goat island, Foster's flats, etc.

This little bivalve is very common in the river at the present time. It is not difficult to understand how these shells were deposited, if one studies the life and habits of the recent forms. The streamlets passing among the rocks that form the Dufferin islands will be found to contain hundreds of these small shells. The bottoms of the pools formed by eddies are white with the accumulation of dead shells, in such quantities that they may be taken up by the shovelful.

Sphaerium stamineum (Conr.) Prime 1865 (Fig. 178). Cyclas staminea Conrad (1834. *Am. jour.* 25:342). Sphaerium stamineum Prime (1865. *Smith. Misc. coll.* no. 145, p. 38)

Shell oval, full and inequilateral; anterior end abrupt; posterior end somewhat distended; beaks full, prominent and sometimes sculptured; striae heavier than in the foregoing species; hinge margin more curved; cardinal teeth double, and not very distinct; lateral teeth stronger.

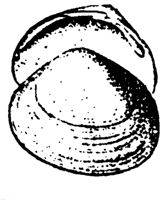

Fig. 178 Sphaerium stamineum. x2

In this, as in the preceding species, specimens frequently occur in which the hinge is reversed.

Localities. Goat island, Prospect park, and near the Whirlpool.

Recent species of this interesting group of fresh-water bivalves abound in Niagara river and its tributaries. While they prefer the soft mud at the bottom, they are frequently found attached to the lower side of branches and floating debris, where they may be seen moving about by means of the long, flexible foot.

Genus PISIDIUM Pfeiffer. 1821

The animal closely resembles that of the foregoing genus, but the siphons are united to the end, those in Sphaerium being separated and more elongated. The shell is trigonal or rounded oval; the cardinal teeth are very small and double, at times they are united and are situated directly under the beaks; the lateral teeth are elongated, lamelliform, double in the right valve, single in the left; the ligament is always on the shorter side.

Pisidium virginicum (Gmelin) Bourg. 1853 (Fig. 179). Tellina virginica Gmelin (1788. ? p. 3236, pl. 159, fig. 15). Pisidium virginicum Bourg. (1853. *Am. Malac.* 1:53)

This is the largest Pisidium found in this region; it is thick and oblique; anterior side very much longer, narrower and more rounded than the posterior side, the latter being much broader and well rounded; beaks prominent and posterior; striae coarse; hinge broad and with two large cardinal teeth; laterals small and delicate.

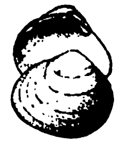

Fig. 179 Pisidium virginicum. x3

Locality. Goat island.

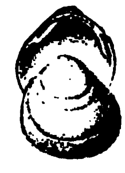

Fig. 180 Pisidium compressum. x5

Pisidium compressum Prime 1851 (Fig. 180). P. compressum Prime (1851. *Bost. soc. nat. hist. Proc.* 4:164)

Shell solid, triangular and somewhat attenuated at the beaks, which are inflated; anterior side longer, narrower and more produced than the posterior; the latter subtruncate; beaks not much inflated; striae distinct and regular; hinge thick, having strong, short teeth; cardinals compressed; laterals placed at an obtuse angle with the hinge.

Locality. Goat island.

Pisidium abditum Hald. 1841 (Fig. 181). P. abditum Haldeman (1841. *Acad. nat. sci. Phil. Proc.* 1:53)

Shell rounded, oval and very thin, somewhat elongated, beaks small, not inflated and placed posteriorly; surface smooth, the growth lines being indistinct; hinge nearly straight; cardinal teeth small, the anterior tooth being larger and more prominent; the lateral teeth not much elongated.

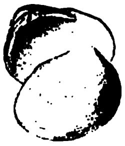

Fig. 181 Pisidium abditum. x2

Locality. Goat island.

Pisidium ultramontanum Prime 1865 (Fig. 182). P. ultramontanum Prime (1865. *Smith. Misc. coll.* no. 145, p. 75)

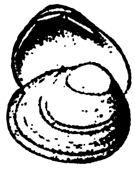

Fig. 182 Pisidium ultramontanum. x3

Shell solid, oval or suborbicular, and remarkably compressed; anterior side much produced between the extremity of the lateral teeth and the junction with the basal margin; posterior margin well rounded; beaks small and only slightly raised above the outline of the shell; the striae very fine and even, and the hinge line straight.

Locality. Goat island.

Pisidium scutellatum Sterki. 1896 (Fig. 183). P. scutellatum Sterki (1896. *Nautilus*, 10:66)

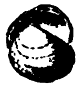

Fig. 183 Pisidium scutellatum. x3

Shell high, oblique, slanting downward anteriorly, well rounded and rather strongly inflated; beaks posterior, rather large and prominent, margins well curved, the surface polished, having irregular growth lines; the hinge fine and short; cardinal teeth lamellar, the one in the right valve moderately curved, its posterior end being thickest; the inferior in the left valve curved; the superior almost straight; the lateral teeth very short, abrupt, pointed and thin, projecting somewhat into the cavity of the shell.

Locality. Goat island.

Genus LAMPSILIS Rafinesque. 1820

Shell inflated, rather thin, and shining, sometimes having a posterior ridge; sculpture coarse at beaks.

Lampsilis rectus (Lam.) Smith 1899 (Fig. 184). Unio recta Lamarck (1819. *Animaux sans vertèbres*, 6:74) Lampsilus rectus Smith (1899. *U. S. fish com. Bul.* p. 290)

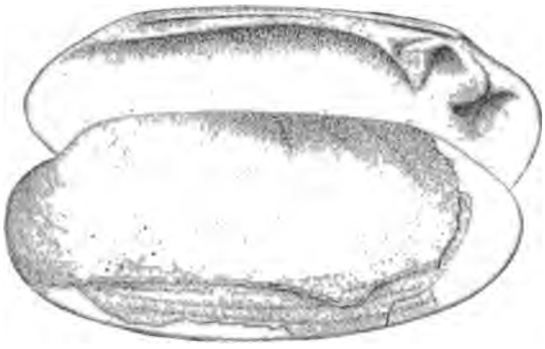

Fig. 184 Lampsilis rectus

Shell large, oblong, ovate, compressed and comparatively thin; surface regularly and smoothly marked by growth lines; anterior end rounded, posterior end slightly angulated; dorsal margins straight or nearly so, hollowed a little back of the beaks; ventral margin straight; adductor muscle impressions well defined; cardinal teeth not large, two on the left valve and one on the right; lateral teeth delicate; beak, in present specimen, smooth, slightly sculptured in recent specimens.

Locality. Goat island.

Lampsilis ellipsiformis (Conrad) Simpson 1900 (Fig. 185).
Unio ellipsiformis Conrad (1836. *Monograph*, 8:60)
Unio spathulatus Lea (1845. *Am. philos. soc. Proc.* 4:164)
Lampsilis ellipsiformis Simpson (1900. *U. S. nat. mus. Proc.* 22:557)

Shell oblong, very compressed, rounded both anteriorly and posteriorly; surface slightly roughened by the growth lines; dorsal margins curved; ventral margins angulated toward the posterior end; anterior adductor muscle impression deep and triangular, slightly pitted; posterior muscle scar broad and oval, showing the ray-like growth lines; hinge area broad and flat; teeth strong, both cardinal and lateral, there being two cardinal teeth in each valve, two lateral teeth in the left valve and one in the right; hinge area between the cardinal and lateral teeth broad and very slightly undulated; pallial line well impressed; beaks low, showing no sculpture, though recent specimens show delicate waves or ridges.

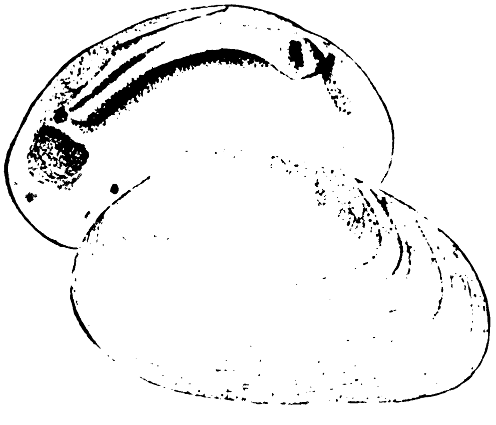

Fig. 185 Lampsilis ellipsiformis

Locality. Found in Prospect park by Prof. Irving P. Bishop.

Genus ALASMIDONTA Say. 1818

The shell is ovate, solid and inflated, shining, with strong beak sculpture. Cardinal teeth thick and strong; the laterals are short, sometimes not present.

Alasmidonta calceola (Lea) Simpson 1900 (Fig. 186). Unio calceolus Lea (1830. *Philos. soc. Trans.* 3:265). Alasmidonta calceola Simpson (1900. *U. S. nat. mus. Proc.* 22:668)

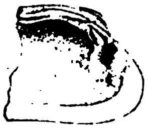

Fig. 186 Alasmidonta calceola

Shell small, solid and inflated; surface smooth; anterior end rounded; posterior end triangular; dorsal margin oval to the umbo, whence it has a deep inward curve, back of and under the beak; ventral margin straight; muscle impressions deep and well defined; pallial line clear; beaks prominent, inflated, more or less sculptured.

Locality. Goat island.

Alasmidonta truncata (Wright) Simpson 1900 (Fig. 187). Margaritana marginata var. truncata Wright (1898. *Nautilus*, 11:124). Alasmidonta truncata Simpson (1900. *U. S. nat. mus. Proc.* 22:671)

Shell elongated, quadrangular and heavy; surface marked by distinct growth lines, which are crossed by transverse wrinkles on the posterior slope; posterior end angulated; anterior end rounded; dorsal margin curved outward at the umbo; ventral margin straight or nearly so; muscular impressions deep, particularly the anterior adductor; pallial line distinct; beaks large, prominent and incurved,

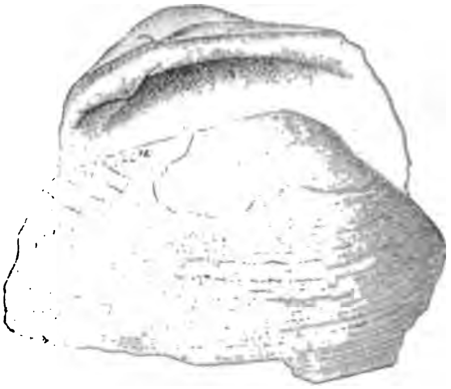

Fig. 187 Alasmidonta truncata

having groove-like sculpture. There are three cardinal teeth, one in the right and two in the left valve; the lateral teeth are strong.

Locality. Goat island.

Genus UNIO Retzius. 1788

The shell is inequilateral, elongated, rounded in front and pointed behind, with a slight posterior ridge; beaks full, slightly sculptured; surface smooth.

Unio gibbosus Barnes 1823 (Fig. 188). Unio nasuta Lamarck (1819. *Animaux sans vertèbres*, 6:75). Unio gibbosus Barnes (1823. *Am. jour. sci.* 6:262)

Shell solid, ovate and elongated; rounded at the anterior end, angulated slightly at the posterior; dorsal margin straight or nearly so; ventral margin oval; muscle impressions deep and well defined; teeth large and strong, the left valve having two cardinals, and two laterals; growth lines coarse; pallial line deep and clear; beaks turncated and slightly sculptured, the sculpture consisting of two or three strong ridges running parallel to the growth lines.

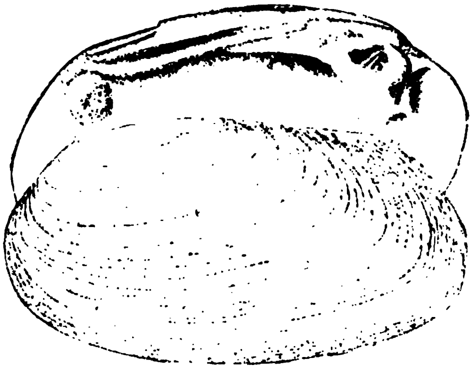

Fig. 188 Unio gibbosus

Found in nearly all the localities. This species seems to have been the most common of the Unios.

Genus QUADRULA Rafinesque. 1820

Shell thick, heavy and solid; teeth large and strong.

Quadrula solida (Lea) Simpson 1900 (Fig. 189). Unio solidus Lea (1838. *Phil. soc. Trans.* 6:13). Quadrula solida Simpson (1900. *U. S. nat. mus. Proc.* 22:789)

Shell oval, solid and thick, surface marked by concentric growth lines; anterior end rounded; posterior end slightly angulated; dorsal margin oval; ventral margin sloping inward toward the posterior end; muscle impressions deep, anterior adductor muscle scar-pitted; cardinal teeth large and heavy; laterals strong and straight or nearly so, with deep, wide impressions; beaks large and prominent, showing no sculpture.

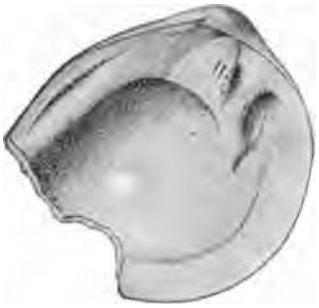

Fig. 189 Quadrula solida

Locality. From excavations in Prospect park.

Quadrula coccinea (Conrad) Simpson 1900 (Fig. 190). Unio coccineus Conrad (1836. *Monograph,* 3:29) Quadrula coccinea Simpson (1900. *U. S. nat. mus. Proc.* 22:788)

Shell quadrate, oval, thick and heavy, somewhat compressed posteriorly; anterior end oval; posterior end produced, angulated; dorsal margin oval; ventral margin rounded anteriorly, produced and pointed at the posterior end; the anterior adductor muscle impression deep, pitted above, triangular, showing radiating lines; posterior adductor impression somewhat indistinct; cardinal teeth large and strong, double in each valve; laterals strong, blade-like, two in the left valve and one in the right; beaks large, produced, showing no sculpture, and widely incurving; dorsal margin excavated at the umbones; surface marked by heavy, regular growth lines, resembling concentric waves.

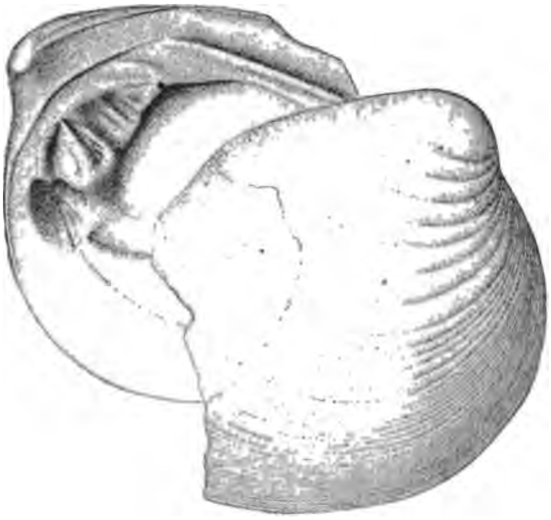

Fig. 190 Quadrula coccinea

Locality. Found in nearly all the deposits.

APPENDIX

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Glossary

aberrant—differing from the type
acanthopores—hollow spines occurring between the apertures, on the frond of a bryozoan
acinus—a berry
adductor muscles—closing muscles in bivalve shells
agglutinate—firmly united
air-chambers—chambers below the living chamber in the shells of cephalopods
alar—pertaining to wings; the lateral primary septa of the tetracoralla
alate—having wing-like expansions
ambulacral areas—perforated areas in the test of an echinoderm, through which the tubed feet project
anastomosing—uniting to form a net work
angulated—with angles or corners
ankylosed—firmly united; grown together
annulations—rings, or ring-like segments
annulus—a ring; a segment of the thorax of a trilobite
antennae—paired articulated appendages of head of arthropod—trilobite
anterior—front
aperture—opening of shells, cells, etc.
apex—terminal or first-formed portion of gastropod shells
apophysis—a calcareous process (in interior of shells, etc.)
appressed—pressed closely against
arcuate—arched; bent like a bow
articulated—joined by interlocking processes, or by teeth and sockets
asperate—rough
attenuated—tapering; or thinning
auricle—ear, or anterior projection of the hinge of many pelecypods
auriculate—eared
aviculoid—resembling Avicula, winged
axial canal—central canal of crinoid stem
axial furrows—furrows or depressions delimiting the axis in trilobites
axis—central longitudinal division of the body of a trilobite
azygous—unpaired; the azygous side of the calyx of a crinoid has plates differing from those of the regular sides

basals—lowest cycle or cycles (in forms with dicyclic base) of plates in the crinoidea
beak—area of the apex or initial point of a shell
biconvex—both valves convex, as in most brachiopods
bifid—split in two
bifoliate—two-leaved
bifurcating—dividing in two, forking

biserial—with double series or rows
brachial—pertaining to the brachia or arms of brachiopods or crinoids; one of the arm plates of crinoids
brachidium—calcareous support of the arms in brachiopods
branchiae—gills
bryozoum—whole compound colony of the bryozoa
bulbiform—bulb-shaped
byssal notch—notch or opening for the emission of the byssus (supporting-threads spun by the foot) in the pelecypoda

calicinal—pertaining to the calyx or cup
callosity—hardened spot or area
callus—thickened part of the inner lip of gastropods, which usually covers portions of the preceding volutions
calyx—1) cup of corals, limited below by the septa; 2) body, exclusive of the arms, of crinoids, cystoids and blastoids
camerate—chambered; an order of crinoidea
camerae—air-chambers of a cephalopod shell
canaliculate—channeled; having a canal
cancellated—marked by lines crossing each other; lattice-like
carapace—hard shell or shield of crustacea
cardinal—pertaining to the area of the beak in brachiopods and pelecypods
cardinal process—process from under the beak of the brachial valve of brachiopods, to which the diductor (opening) muscles are attached
cardinal quadrants—two quadrants of a Tetracorallum which bound the main, or cardinal, septum
cardinal septum—first or main of the four primary septa of a Tetracorallum; the cardinal septum has the pinnate arrangement of the secondary septa on both sides
cardinal teeth—teeth under the beak in the pelecypods; teeth in the pedicle valve of the brachiopods
carina—projecting ridge running down the center of the branches in some fenestelloid and other bryozoa; the projecting ridges on the septa of Heliophyllum and other corals
carinated—having a ridge or keel
cartilage—compressible, elastic substance between the hinge-margins of the valves of pelecypods. The cartilage is the internal, as the ligament is the external medium for opening the valves
cast—the impression taken from a mold
caudal—pertaining to the tail
celluliferous—cell bearing (bryozoa commonly have a celluliferous and a non-celluliferous side)
cephalic limb—anterior border of the cephalon of a trilobite
cephalon—head-shield of trilobites
cephalothorax—combined head and thorax of crustacea
cercopods—lateral tail spines in the ceratiocarida

cespitose—matted, tangled or growing in low tufts

cheeks—lateral portions of the cephalon, divided into fixed and free cheeks, of a trilobite

chelae—pincer-like claw terminating some of the legs of crustacea

chilidium—covering for the chilyrium

chilyrium—triangular opening under the beak of the brachial valve in those brachiopods in which that valve is furnished with a hinge area

chitinous—composed of chitin, the substance forming the horny wings or elytra of beetles, and the carapaces of crustacea

cicatrix—a scar

cincture—depression anterior to the beak in the shell of some pelecypods

cirri—root-like appendages to the stem of crinoids

clastic—consisting of fragments, i. e. rocks made of fragments of older rocks

clavate—club-shaped

clavicle—heavy internal ridge running downward from the beak in some pelecypods

columella—central or axillary rod

compound corallum—made up of corallites, either separate or closely joined by their walls (ex. Favosites)

composite corallum—compound corallum with coenenchyma or extrathecal calcareous tissue connecting the corallites (ex. Galaxia and many other recent forms)

concavo-convex—shells of brachiopods are normally concavo-convex, when the brachial valve is concave, and the pedicle valve convex; reversed or resupinate, when the reverse condition obtains

confluent—blended so that the line of demarcation is not visible

coniferae—order of arborescent plants to which the pines, firs, etc. belong

consequent stream—type of stream which flows down the original constructional slope of the land

corallites—individual tubes of a compound corallum

corallum—calcareous skeleton of a single, or of a colonial, coral stock

corneous—horny

coronal—crown-like

costae—extrathecal extensions of the septa of the corals

costals—first brachial or arm-plates of the crinoids lying between the radials and the first bifurcation of the arms

counter quadrants—quadrants bounding the counter septum of a Tetracorallum

counter septum—front primary septum of the Tetracoralla, opposite the cardinal septum; the secondary septa are parallel to it

crenulated—notched to produce series of teeth

crura—apophyses to which the brachidium of the brachiopods is attached

cuesta—topographic relief element, resulting from the normal dissection of a coastal plain composed of alternating harder and softer strata (see p. 40)

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escutcheon—depression behind the beak of the pelecypod shell

exfoliate—peeling off

exothecal—outside of the theca of corals

explanate—spread out in a flat surface

extrathecal—outside of the theca of corals

extroverted—turned base to base; applied to spirals of brachiopods

facetted—having facets or numerous faces as the eye of an insect, etc.

facial sutures—sutures in the cephalon of trilobites which separate the free from the fixed cheeks

facies—local characteristics

falcate—curved like a scythe or sickle

fasciculate—clustered

fathom—a measure of length equaling 6 feet used chiefly for depths of the sea

fenestrule—open spaces between the branches and dissepiments of a fenestella frond

filament—a fine thread or fiber

fimbriae—a fringe

fixed cheek—that part of the cephalon of a trilobite which lies between the glabella and the facial suture

fission—the act of splitting or cleaving into parts

flabellate—fan-shaped

flange—a projecting rim

flexibilia—an order of crinoids characterized by the loose jointing of the plates of the calyx

fold—the central elevation of the valve, usually the brachial of a brachiopod

foliate—leaf-like; in the form of a thin leaf-like expansion

foramen—an opening or pore; specifically the opening for the pedicle in the pedicle valve of the brachiopoda

fossula—groove in the calyx of a coral, usually due to the abortion of a septum

free cheeks—lateral portions of the cephalon of trilobites separated off by the facial sutures

frond—foliaceous or leaf-like expansion of the skeleton of bryozoa and other organisms

fruticulose—resembling a small shrub

fucoid—a seaweed, particularly of the type similar to the modern Fucus, or rockweed

galeate—with a helmet-like covering

gastric—pertaining to the stomach

genal angles—posterior lateral angles of the free cheeks of trilobites

genal spines—posterior prolongations, or spines, of the free cheeks of trilobites

geode—a hollow concretion usually lined with crystals, but also filled completely with foreign mineral matter

geodiferous—containing or abounding in geodes
geodetic—geode-bearing, pertaining to geodes
gibbous—swollen or humped
glabella—central, most prominent portion of the trilobite cephalon, bounded by the fixed cheeks
glomerate—growing in dense heads or clusters, generally of an irregular character
gonopolyp—reproductive polyp of Hydrozoa
granulated—having small and even elevations resembling grains
granulose—bearing or resembling grains or granules

hexacoralla—class of corals built on the plan of six
hinge area—flat area bordering the hinge line of many brachiopods
hinge line—line of articulation
hydrocoralline—order of Hydrozoa which build calcareous skeletal structures
hydroid—animal belonging to the class of Hydrozoa
hydrotheca—cup inclosing the nutritive polyp in thecaphore Hydrozoa
hyponome—water tube, or squirting organ, of squids, cuttlefish, and other cephalopods
hypostoma—underlip of the trilobites, usually found detached

imbricate—overlapping serially
implantation—planting between, as a new plication suddenly appearing between two older ones
inarticulate—not articulating by teeth and sockets; of brachiopoda
incised—cut into
incrusting—covering as with a crust
inequilateral—having unequal sides
inface—steep face or escarpment of a cuesta, facing toward the old-land
inferior—lower in position
inflated—distended in every direction and hollow within
inflected—bent or turned inward or downward
infrabasals—lower cycle of basal plates in the crinoids with dicyclic base
infundibuliform—funnel-shaped
inosculating—connecting, so as to have intercommunication
interambulacral—between the ambulacra
interapertural—between the apertures
interbrachials—plates in the calyx of a crinoid, lying between the brachials
intercalation—irregular interposition
intercellular—between the cells or meshes
interdistichals—plates in the calyx of a crinoid, lying between the distichals
interradials—plates in the calyx of a crinoid, lying between the radials
interstitial—pertaining to an intervening space; between lines, plications, etc.
intervestibular—between the vestibules or circumscribed areas
interzooecial—between the zooecial tubes in bryozoa, etc.

intrathecal—within the theca; endothecal
introverted—turned apex to apex; applied to the spirals of brachiopods
involute—rolled up, as a Nautilus shell

joints—component segments of the stem of a crinoid
jugum—yoke-like connection between the two parts of the brachidium of a brachiopod

keel—strong central carina or ridge (Taeniopora)

lacrymiform—tear-form; drop shaped—pear shaped, but without the lateral contractions
lamellar—disposed in lamellae or layers
lamellibranch—leaf-gilled, the class of molluska with bivalved shell, to which the oyster and clam belong; pelecypod
lamelliform—having the form of a leaf or lamella
lamellose—made up of lamellae
lamina—a thin plate or scale
lateral gemmation—a budding from the sides, as in some corals
lateral teeth—ridge-like projections on either side of the beak, in the interior of lamellibranch shells
laviformia—primitive order of crinoids
ligament—external structure for opening the valves in the pelecypoda
limb—lateral area or marginal band of the cephalon of trilobites on either side of the glabella, corresponding to a pleuron of the thoracic region
lines of growth—lines marking the periodic increase in size, in shells
linguiform—tongue-shaped
linguloid—tongue-shaped; like Lingula
lip—margins of the aperture of univalve shell
listrium—depressed area surrounding the pedicle opening in the pedicle valve of Orbiculoidea and other discinoid brachiopods
lithic—pertaining to stone
living chamber—the last chamber in the shell of a cephalopod, which is occupied by the animal
lobes—backward bending portions of the suture of cephalopod shells
lophophore—ciliated or tentaculated, oral disk of bryozoa; the oral disk and brachia of brachiopods
lunarium—more or less thickened portion of the posterior wall of the cell in many paleozoic bryozoa, which is lunate or curved to a shorter radius, and usually projects above the plane of the cell aperture
lunule—depression in front of the beak of pelecypod shells

macerate—softening and disintegrating by immersion in water
macrocorallites—the larger corallites in a compound corallum
maculae—irregular, usually depressed, areas on the celluliferous face of a bryozoan frond, which are free from cells, or otherwise differentiated
mandibles—first upper or outer pair of jaws of crustacea and insects

mantle—fleshy membrane infolding the soft parts of mollusks and brachiopods and building the shell
medullary rays—the "silver grain" or radiating vertical bands or plates of parenchyma in the stems of exogenous plants
medusa—a jelly fish
membranaceous—pertaining to a membrane
mesial—central
mesogloea—central, non-cellular layer in the body of coelenterates
meso-pores—irregular meshes or cysts on the intercellular spaces of certain bryozoa
mesotheca—median wall separating opposed cells in certain bryozoan fronds
metastonia—underlip of crustacea, composed of small pieces immediately below and behind the mouth
microcorallites—smaller corallites of a compound corallum
mold—any impression of a fossil, in rock matrix, external or internal
moniliform—resembling a necklace or string of beads
monocyclic—of a single cycle
monticuliporoids—corals belonging to the order Monticuliporidae having many points of resemblance with the bryozoa
monticules—elevated areas on the surface of certain coral and bryozoan colonies, commonly carrying larger apertures
mucronate—produced into a long pointed extension
mural pores—pores in the walls of the corallites of the Favositidae
muscle scar—scar in a shell marking the former attachment of a muscle

nacreous—pearly; the nacreous layer of shells is the inner smooth pearly layer
nariform—shaped like a nostril
nasute—projecting, nose-like
nettlecell—one of the nematocysts or stinging cells found covering the tentacles and other body parts of most Coelenterata
node—knob; usually considered as ornamental
nodose—bearing nodes or tubercles
nodulose—knotty, or having nodes

obconical—inversely conical
oblate—flattened at the poles
obovate—inversely ovate or egg-shaped
obsequent stream—a stream flowing down the inface of a cuesta, or toward the old-land, tributary to the subsequent stream which in turn flows into the consequent
occipital—applied to the posterior part of the cephalon of a trilobite
occipital furrow—transverse groove on the cephalon of trilobites, which separates the last or occipital ring from the rest of the cephalon
occipital ring—posterior division of the glabella of a trilobite cephalon
operculiform—resembling an operculum
operculum—lid or cover

paddles—large or last pair of thoracic legs of the eurypterids
pallial line—line on the interior of the shell of mollusks marking the attachment of the mantle
pallial sinus—reentrant angle in the pallial line usually at the posterior end of the shell of pelecypods; it marks the attachment of the siphon muscles
palmars—third series of brachial plates of the Crinoidea, lying above the axillary distichals
palmate—palm-shaped
palpebral lobes—supra-orbital extensions from the fixed cheeks of trilobites
papilla—a small nipple-shaped protuberance
papillose—covered with papillae or fine projections
parabasals—second cycle of basal plates in crinoids
pectinated rhombs—paired pore clusters in the calyx of certain cystoids (Callocystites)
pedicle—fleshy peduncle or stem used for attachment in the brachiopoda
pedicle valve—valve which gives emission to the pedicle in the brachiopoda. Ventral of most authors. Usually the larger valve
pentameroid—five chambered, similar to Pentamerus
pentapetalous—resembling a five-petaled flower
penultimate—next to the last
periderm—outer chitinous covering of Hydrozoa
periostracum—epidermis or outer organic coating of shells
peripheral—pertaining to the circumference
peristome—margin of an aperture, i. e. the mouth of a univalve molluscan shell, the mouth of a bryozoan cell, etc.
peritheca—epithecal covering which surrounds a colony of corallites, i. e. a compound corallum
petaloid—resembling a leaf or petal
pinnate—shaped like a feather
pinnulate—provided with pinnules
pinnules—finest divisions of the arms of crinoids
plano-convex—normally in brachiopods, with the pedicle valve convex and the brachial valve flat
pleura—lateral portions of the thoracic rings of trilobites
plicate—plaited or folded
plications—folds or rib-like plaits of a brachiopod shell
polyp—animal of a simple coelenterate or bryozoan
polypite—individual polyp of a colony
pore-rhombs—pore clusters, arranged in rhombic manner in the calyx of cystoids
poriferous—pore-bearing, corals which like Favosites are furnished with several pores
posterior—situated behind

post-palmars—all the plates, superior to the axillary palmars in the arms of crinoids
prehensile—adapted for seizing
preoral—situated in front of the mouth
produced—drawn out, elongated
proliferous—reproducing buds from the calyx
protoconch—embryonic shell of a cephalous molluscan
proximal—nearest or basal portion
pseudocolumella—false columella in corals, formed by a twisting of the septa
pseudodeltidium—false deltidium (Spirifer), formed by union of the two deltidial plates
pseudosepta—septa-like ridges of Chaetetes, etc., the projecting ends of the lunaria in the cells of certain bryozoa
pseudotheca—false wall or theca in some corals, formed by the expansion of the outer margins of the septa
punctate—dotted, with scattered dots or pits
pustule—small blister-like elevation
pustulose—bearing pustules or projections
pygidium—posterior or tail portion of the carapace of trilobites
pyramidal—having the form of a pyramid
pyriform—pear-shaped
pyriformis—pear-shaped

quadrangular—four angled
quadrate—with four equal and parallel sides
quadrifid—cut into four points
quadrilobate—bearing four lobes
quadriplicate—with four folds
quincunx—five objects arranged in a square with one in the middle

rachis—central stem of a frond in bryozoa, etc.
radials—main plates of the calyx of a crinoid, resting on the parabasals, and alternating with them
radii—ribs or striations diverging from the beak of a shell
ramose—branching
ramus—branch of a skeletal structure
reniform—kidney form
resilium—internal cartilage or compressible substance in the hinge of pelecypods
reticulated—like a network
retractile—capable of being withdrawn
retral—backward
rhynchonelloid—resembling Rhynchonella
root—expanded basal portion of a crinoid stem, used for fixation
rostrum—a beak or snout
rugosa—an old name for the Tetracoralla

saddles—forward bending portions of the suture in the shells of cephalopods

salient—standing out prominently

scabrous—rough or harsh with little projecting points

scalae—small transverse plates in the genus Unitrypa of the bryozoa

scalariform—stair or ladder-shaped

sclerenchyma—calcareous tissue deposited by the coral polyps

scorpioid—scorpion-like, coiled like the tail of a scorpion

semilunar—crescentic, or resembling a half moon

semiovate—half egg-shaped

senile—pertaining to old age

septal radii—radiating ridges taking the place of septa in certain corals

septate—with partitions or septa

septum—partition; in corals, the radiating calcareous plates; in cephalopods, the transverse partitions between the chambers

serrate—notched like a saw

setiferous—bristle-bearing

sigmoid—curved like the Greek letter Σ (sigma)

sinistral—left handed, reversed coiling of some gastropod shells

sinuate—wavy, winding

sinuosity—notch or incision forming a wavy outline

sinus—impression in the surface or margin of a shell

siphonal funnel—siphonal projection from the septum of a cephalopod shell

siphonal lobe—lobe in the suture of an ammonoid shell, corresponding in position to the siphuncle

siphuncle—tubular canal passing through the air chambers in the shells of cephalopods

slickensides—polished or striated surfaces on rock due to motion under great pressure

sockets—hollows in the brachial valve of brachiopods for the reception of the teeth of the opposite valve

spatulate—shaped like a spatula; spoon-shaped

spheroidal—globose, of the form of a spheroid

spiniform—spine-like

spinulose—spine bearing

spondylium—spoon-shaped cavity under the beak of pentameroid brachiopods

squamous—scaly, covered with scales

stalk—stem of crinoids

stellate—star-shaped; arranged in star-like manner

stipe—stalk or stem in plants

stock—main stem or trunk

striae—fine radiating surface lines of shells

stylolites—peculiar columnar and striated rock form seen in limestones at the junction of two layers

sub—in composition indicates a low degree: sub-angular—rather angular; sub-carinate—somewhat toothed, etc.

subfusiform—more or less spindle-shaped
subglobose—more or less globose
sublunate—approaching the form of a crescent
suborbicular—nearly circular
subpentahedral—irregularly five-sided
subpyramidal—approximately pyramid-shaped
subquadrangular—between quadrangular and oval
subquadrate—nearly but not quite square
subspheroidal—imperfectly spheroidal
subtruncate—irregularly cut off
subturbinate—approaching top shape
sulcation—a furrow or channel
sulcus—a furrow
superior—higher in position
suture—in cephalopods, the line of junction between shell and septum, seen on breaking away the former; in gastropods, the external line of junction between the several whorls; in trilobites, the dividing line between fixed and free cheks, commonly called *facial suture;* in crinoids, the line of junction between adjacent plates
tabulae—transverse, continuous partitions or floors in corals, etc.
tabulate corals—group of corals in which the tabulae cross plates are prominent, while the septa are faintly or not at all developed e. g. Favosites, Aulopora, etc.
talus—the mass of rocky debris which lies at the base of a cliff, having fallen from the face of the cliff above
teeth—articulating projections on the margins of the valves of bivalve shells
tegmen—vault or cover of the calyx in crinoids
terebratuloid—like the recent genus Terebratula
terete—cylindric or slightly tapering terrigenous—derived from the land test-shell
tetracoralla—the old group of rugose corals, built on the plan of four
tetrameral—on the plan of four
theca—the proper wall of the individual corals
thoracic—pertaining to the thorax
thorax—central part of the body of the trilobites
trabeculae—projecting bars
trigonal—three-angled
trihedral—with three equal faces
tripartite—divided into three parts
tripetalous—three leaved or petaled
trochiform—in form like a Trochus or top shell
tubercle—small swollen projection
tuberculiform—in form like a tubercle
tuberculous—having or resembling tubercles
tubicola—an order of marine worms which build calcareous or other tubes
tumid—swollen, inflated
turbinate—top-shaped

umbilicus—external opening of the hollow axis of a loose coiled shell
umbo—area about and including the beak in pelecypods and brachiopods
unconformity—irregularity in the succession of rock beds indicating an intervening period of erosion

valvular—pertaining to a valve
varix—row of spines, a ridge or other mark, denoting the former position of the lip on the shell of a gastropod (plural varices)
vaulted—arched
ventral—pertaining to the lower side, or venter
ventricose—strongly swollen, or bulging
vesicular—bearing vesicles, or hollow cavities
vestibular area—area surrounding the cell apertures of some bryozoa; often depressed
viscera—the internal organs of the body

whorl—single volution of a coiled shell
wing—posterior larger expansion along the hinge-line of a pelecypod

zoarium—aggregates of the polypites of a bryozoan colony
zooecium—the bryozoan cell
zooid—one of the " persons " or individuals of a zoarium

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UTILIZATION
OF
WATER POWER
AT
NIAGARA FALLS.

By A. Howell Van Cleve C. E.

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Utilization of Water Power at Niagara Falls.

Few branches of Engineering show more clearly the rapid progress of the age in which we live than the advancement made during the past fifteen years in the art of water power development. Nearly all of us can remember the time when the word "water-wheel" was associated in our minds with the rustic grist mill with its stagnant pond, its moss covered shingles, and its slowly revolving overshot wheel. Such mills seemed to have come to us as a legacy of the past. They had no place in the strenuous, hurrying life of the age of steam. It is no wonder that they formed a favorite subject for the artist who wished to depict an idyllic scene or a common theme for the pastoral poet. The dull, monotonous rumble of the grindstones, the groaning of the wooden shaft come back to us from our childhood days with the picture of the sleeping miller, of cattle standing knee deep in water and all the myriad sights and sounds of a drowsy August day. Little did we think then that in a few years the utilization of the power of falling water would form such a chapter in our national development and in the history of our material prosperity. It seemed that except in isolated cases water power development was doomed to be left far behind in the race with steam. But what a wondrous change has now appeared. Every water-fall in settled communities is carefully examined, companies are formed to develop its power, vast capital is invested and some of the best engineering talent in the country is employed in its utilization. Such is the result of the past decade and yet the work is only begun.

What has caused this wondrous change? What mighty magician has wrought this transformation? The question may be answered in one word,—"Electricity." Thinking scientists had long deplored the decadence of water power and had carefully investigated its causes. They found that it was largely due to the fact that water-falls were usually situated at inconvenient locations, far removed from the centers of population and without proper facilities for the transportation of raw materials or finished products. They had therefore reached the conclusion that the crying need was the transmission of the power developed by water wheels, and rope drives, compressed air, water under high pressure and other forms of power transmission were in turn experimented with but each was found to have its limitations, and it is only in the past few years that electrical engineering with its wonderful discoveries has practically solved the problem and made available at the factory the power of the distant stream. Hence water falls that a few years ago were considered only as obstructions to navigation are now of great value. The very language shows the effect of the change. A few years ago we spoke of water-falls, now we speak of water powers.

A few figures may be interesting in this connection. According to Census Bulletin No. 247 the water power used in manufactures in 1880 equalled 1,225,000 H. P.; in 1890 1,263,000 H. P.; in 1900 1,727,000 H. P.; the increase from 1880 to 1890 being 3.1%, while from 1890 to 1900 the increase was 36.7%. The figures for 1900 do not include water power employed for generating electricity used in manufactures, which would probably add 200,000 H. P. to the amount of water power above mentioned, thus making the increase for the last decade of the 19th century not less than 50%. During the same period the amount of water power developed in the State of New York was practically doubled.

Of all the water power developments that marked the close of the last century none was on so large a scale, none has attracted such world-wide interest, and none is of such importance to citizens of Buffalo and its vicinity as the utilization of the power of Niagara Falls. It is true that the power of this river was used as early as 1725 when the settlers operated a saw mill on the rapids above the Falls, but it was not until after the year 1890 that power development at Niagara assumed more than a local interest. With the success of electrical generation and transmission there commenced a new phase in the history of industrial Niagara and it is with this later form of power utilization that we are concerned tonight.

There is of course nothing new in the idea of utilizing Niagara's energy. Every man of a mechanical turn of mind who ever contemplated the resistless force of its falling water has been impressed with the fact that vast industrial progress would result from the diversion of even a small proportion of this power into useful channels. Among those who many years ago felt the mighty power of the falling waters and contemplated the results of using it to produce useful mechanical power was the famous Dr. Siemens, who in a lecture delivered in 1877 before the Iron and Steel Institute of Great Britain referred to his impressions of Niagara and stated that all the coal raised at that time throughout the entire world would be required to produce energy equal to that produced by the falls alone, without considering the force of the rapids. This statement may have been somewhat exaggerated but the following figures are believed to be accurate. The total difference in level of Lakes Erie and Ontario is 328 feet. The minimum flow in the Niagara River, as observed by the government engineers is 178,000 cubic feet per second. The total energy represented by this amount of water in passing from one lake to the other therefore equals 6,635,000 H. P. or in passing from the upper river above the rapids to a point above the lower rapids equals 4,380,000 H. P. But such figures are like those representing the capital of the steel trust, (although this is not entirely a "water" power), or the distance to the nearest fixed star—they convey but little meaning. But take, as an example, the energy produced by a single cubic foot of water per second in dropping from the upper river to a point below the falls, which is 25 H. P. That does not seem a large amount in these days of large numbers, but what does it represent? A force sufficient to raise a one pound weight 2½ miles in one second, to raise a large sized passenger locomotive to the height of a man's head in one minute, or to raise an audience of 500 people from the floor to the ceiling of an ordinary room in one minute. And this is done by a bucket of water. Perhaps this may give us some idea of the power that has carved the history of the ages on the rocky walls of Niagara's gorge.

To utilize a portion of this enormous power four great companies are now at work and a fifth is about to commence operations. It is the object of our talk to-night to give a brief outline of the plans of each of these companies and to call your attention to such points in their several plans of development as may be of special interest.

The first company to engage in the development and sale of power on a large scale was the Niagara Falls Hydraulic Power and Manufacturing Co. The plan under which this company is working was outlined by Augustus Porter of Niagara Falls in 1847. Previous to that time a few water wheels had been operated from a canal above the falls and a paper mill had been built on Bath Island, but Mr. Porter sought for some method of development that would not mar the scenic features of the falls and therefore proposed that a canal should be cut from the upper river, just above the rapids, to a point on the top of the high bank of the river below the falls, the water from such canal to be discharged into the lower river after operating wheels set below the level of the ground surface. The almost level surface of the ground between the points of entry and discharge and the substantial character of the rock through which it would pass made the project an ideal one. Nevertheless Mr. Porter failed to interest capital in this project and it was not until after his death that work was commenced. Even then the excavation of the canal was carried on intermittently by various parties until in 1861 Horace H. Day completed a canal 4,400 feet long, 36 feet wide and 8 feet deep. At the lower end of this canal was constructed a basin or forebay, parallel with the face of the cliff and about 350 feet from it, the present size of this basin being 70 feet by 600 feet although it was, of course, much smaller at first. Even then the opportunities of the power do not appear to have been appreciated and it was not until 1870 that the first mill was built to use water from this canal. In 1877 the canal and the property and rights belonging thereto were purchased by Mr. Jacob F. Schoellkopf and Mr. A. Chesborough who organized the present company. The number of mills utilizing this source of power has steadily increased until at the present time the various industries in the lower milling district (so called) develop about 7,500 H. P. including that in use in the lower mill of the Cliff Paper Co. Most of these factories have constructed their own wheelpits and installed their own wheels.

A good indication of the progress made in hydraulic development in the last few years is the fact that the original grants of the Hydraulic Power and Manufacturing Co. did not include the slope of the bank between the bottom of the vertical cliff and the edge of the lower river, giving a right to excavate only 100 feet below the top of the bank, as it was considered that wheels would never be constructed to operate under a greater head than this, and it was not until 1886 that the Hydraulic Co. secured deeds for this lower slope. As a matter of fact none of the mills thus far mentioned utilized a head of more than 50 or 60 feet and many of them used a still lower fall. The consequence is that an engineer when looking at the cliff below these mills and seeing the large amount of water falling from the outlets of the various wheelpits is impressed with the vast amount of power going to waste. At least 10,000 H. P. is thus lost, or enough to supply all the industries of many a good sized city.

In 1881 the Niagara Falls Hydraulic Power and Manufacturing Co. installed their first plant for supplying power. This consisted of a shaft 20 feet by 40 feet sunk to a depth of 80 feet, 200 feet back from the edge of the cliff, a discharge tunnel being carried from the bottom of this slot to the face of the high bank. Water from the canal was led through iron penstocks to two wheels located in this pit. These wheels have vertical axes, one being of 1,000 H. P. and one of 500 H. P., the head employed being 75 feet. The power from these wheels is transmitted to customers by rope drives and belting, the length of such transmission being inconsiderable. A third wheel with a capacity of 600 H. P. with horizontal shaft has since been placed in this wheelpit.

In 1892 the Niagara Falls Hydraulic Power and Manufacturing Co. commenced to enlarge their canal to a width of 70 feet and a depth of 14 feet. In the same year a change was made in the plan of development and a system inaugurated which was in many respects similar to that now employed. The Cliff Paper Mill desired additional power for grinding pulp and as the capacity of the original canal was exhausted and they were not willing to wait for the completion of the canal extension, it was determined to use the discharge water from the wheels then installed in the wheelpit above described. Accordingly a new tunnel was driven from the face of the cliff to connect with the bottom of the wheelpit and the discharge water was thus led to a steel penstock 8 feet in diameter laid on the same slope as the talus. In case sufficient water is not discharged from the upper wheels an arrangement is provided for admitting water from the basin directly into the upper tail race. The loose rock was cleared from the top of a layer of red sandstone lying just above the water of the lower river. On this surface was built a two-story pulp mill, the lower story containing four water wheels having a total capacity of 2,500 H. P. These wheels are fed from a ten foot receiver connected with the penstock. Three of these are directly connected with the wood grinders and one wheel is used to drive a generator operating the paper making machines in the upper mill. This was one of the first, if not the first instance of electricity being used for operating paper making machinery. The wheels operate under a head of 125 feet, are 66″ in diameter and are of the inward flow type on horizontal axes. Like all the turbines used by the Hydraulic Power and Manufacturing Company, these wheels are of American design. An inclined conveyor is used for transportation of men and materials between the upper and lower works.

The plant for the Cliff Paper Co. was the fore-runner of the present electrical power plant of the Hydraulic Co. As soon as the company saw that electrical generation and transmission was an assured success and that Niagara Falls was destined to become one of the great electro chemical centers a line of pipe was laid from the basin to the edge of the lower river and water under a head of 210 feet thrown from a giant nozzle or "Monitor" commenced to wash away the rock that for ages had fallen from the bank above to the shores of the gorge below. A level strata near the waters edge was cleared, the fallen boulders were used for masonry and a power house 100 feet wide was built immediately below the old mills, being located a short distance above the upper steel arch bridge. To this power house water was led from the basin above in a steel penstock 11 feet in diameter. Successive additions have been made to this power house and two more penstocks have been added, one 11 feet in diameter and one 8 feet in diameter. The canal has been excavated to a width of 100 feet and a depth of 18 feet until it has a capacity of about 100,000 H. P. at a velocity of 4 feet per second. The power house below the bank now contains the following turbine wheels, viz:—3 of 1650 H. P.; 1 of 1900 H. P.; 4 of 2300 H. P.; 1 of 2800 H. P.; and 5 of 2900 H. P. An exciter wheel of 250 H. P. is about to be installed. Your attention is called to the fact that these wheels operate under a head of 210 feet, one of the highest heads used in the East on turbine wheels. Each wheel is of the outward flow type with horizontal shafts. Water from the penstocks enters steel receivers placed beneath the floor and thence to the wheels through 60″ pipes controlled by hydraulically operated gate valves. The supply pipes enter the bottom of each wheel case at the center and the water is discharged through two draft tubes, one on each side. The level of the tail race into which the draft tubes discharge is maintained several feet above the average level of the lower river so that the wheels are said to work under a practically constant head. Two dynamos are directly coupled to each wheel 4 of these being direct current machines and 24 alternating current machines. Two 11,000 volt alternators and an exciter dynamo will be installed in April. The voltage of most of the dynamos is very low, the current being transmitted to the top of the bank only through copper and aluminum bars and cables. The plant therefore presents at present no interesting problems in transmission of power, but the 11,000 volt dynamos are for transmission of power to the new factory district at the north end of the city of Niagara Falls.

From the above details a figure to be carried away with you to-night is that the wheels now installed by the Hydraulic Power and Manufacturing Co. and its customers have a total capacity of 38,000 H. P., an amount approximately equal to the total power at Holyoke. Very important is the announcement that a new power house with a capacity of 50,000 H. P. is about to be commenced. This power house will contain high voltage dynamos and will be used for supplying new industries in the district just mentioned. Niagara Falls will then contain three great factory districts using an amount of electrical power far exceeding that of any city in the world which employs water as its motive force.

In the year 1885 there came to Niagara Falls in the course of his professional services for the State of New York an engineer whose name should ever be remembered by those interested in the commercial prosperity of the Niagara Frontier, Thomas Evershed, the man with the idea. Engaged in plans to prevent the spoilation of one of the most sublime of nature's spectacles, he saw that such plans were not inconsistent with the utilization of a part of the enormous power represented by Niagara's falling waters. He believed that by driving a tunnel from the lower river to a point above the mouth of the Hydraulic Power Company's canal such tunnel could be used for the discharge of water from the upper river after it had done its work in the generation of power. This idea of a discharge tunnel was not entirely a new one, as it had previously been employed at St. Anthony's Falls on the Mississippi, but the application of this principle to Niagara had apparently never been suggested until it was advocated by Mr. Evershed. Having the courage of his convictions he soon interested local business men in his scheme and a company of eight was formed which on March 31st, 1886, obtained from the State of New York a special charter which permitted the diversion of sufficient water from the upper river to generate 250,000 H. P. On June 1st, 1886, Mr. Evershed issued his first formal plan and estimate to which the attention of capitalists was soon attracted and in 1889 was formed a strong combination of men whose financial reputation was world-wide. They organized the Cataract Construction Co. to build the plant of the Niagara Falls Power Co., the parent Co. The Cataract Construction Co has now practically gone out of business, the investors who formerly composed it having acquired a controlling interest in The Niagara Power Co. and continuing operations in its name. The plant of this company, especially in its earlier stages, has been so fully described in both the engineering press and in the local papers that its principal features are familiar to you all and it is the intention of the present lecture to call attention to only the more unusual or interesting of its details with such a brief description of its general plans as may be necessary to an understanding of such details.

In the first place consider the main conception,—a tunnel 1¼ miles long, 200 feet beneath the surface, with an area of 335 square feet, designed to carry water at the rate of 29 feet per second, an aqueduct such as was never before built in the history of man—a conception such as could come only to a man with an imagination, an imagination touched by the inspiration of the great cataract within whose sound he had toiled so long. Its immensity may impress us more when we think that when running to its designed capacity such a tunnel will carry enough water in one minute to supply a city of 10,000 inhabitants with drinking water for a year and a quarter.

Mr. Evershed's plan was no sooner formulated than it received severe criticism and eminent men condemned it as impracticable. Fortunately for Buffalo the results have amply proven the incorrectness of such criticism. The faith of the investors was not shaken and the preparation of working plans was immediately begun. In order that such plans might be as perfect as possible an International Niagara Falls Commission was formed June 1890 composed of five noted engineers from America, England, France and Switzerland. Competitive design for power development were invited, prizes amounting to 22,000 dollars were offered and by January first 1891 22 designs were received from engineers dwelling from Buda Pesth to San Francisco. From these designs that of Faesch & Piccard of Geneva, Switzerland, was considered worthy of first prize and they proceeded with the design of the turbine wheels. It was decided that such wheels were to work under a head of 136 feet and after several modifications it was determined to place the wheels in one long slot in the rock, the end of such slot to be connected with the tunnel.

The form of wheels and their general arrangement having been decided upon, the next question that arose was the form in which their power should be employed and the method of its transmission. This may seem a very easy question to-day but look backward and put yourselves in the position of the engineers of 13 years ago. There were then only 3 examples of commercial electrical power transmission in the world, all of them in France, where power was transmitted for a short distance. Mr. George Westinghouse stated as his opinion that power could be transmitted from Niagara Falls to Buffalo by compressed air only. (Fortunately for Mr. Westinghouse's business he was mistaken) In spite of the meagre knowledge of electrical generation and transmission, it was decided in December, 1891, to ask for competitive plans and estimates for the generation of electrical power and its transmission, both locally and to Buffalo. After a thorough study of these plans the general form of dynamo was decided upon and a contract was let for the construction of three 5000 H. P. two phase alternating current 2200 volt machines at 25 cycles per second. You say you do not see anything very remarkable about that, that nearly every little water power plant in the country produces alternating current. Yes, it seems very easy after it has been done and proven successful, but it should be remembered that in 1891 nearly every great scientist in the world advised against the use of alternating currents and great credit should be given to the far-seeing wisdom of those who decided that the greatest plant in the land should use this form of energy. As a further example of the courage required to make the decision to generate electric power it may be remarked that in 1890 there was in use in the United States only 15,569 E. H. P., nearly all direct current. So the Niagara Falls Power Co. proposed to double by their first installation of three 5000 E. H. P. wheels the amount of electrical power employed in the whole country. The size of the units employed is also worthy of notice for while they have since been exceeded they were a great step in advance at a time when no dynamo of more than 2500 H. P. had been put in successful operation.

The general form and size of the wheels and the method of generation having been decided upon the next step was to plan the general arrangement of the station. It was decided to build a canal whose outer end should project about 600 feet beyond the then shore line, the lands under water to the outer end of the canal being filled with the excavated material. After many studies the mouth of the canal was located about 1400 feet above the mouth of the Hydraulic Company's canal. This head race had a width of about 180 feet at the mouth, 100 feet at the upper end, was 1500 feet long and 12 feet deep. When 100,000 H. P. is being developed from water supplied from this canal the maximum velocity in it will be about 4 feet per second. It is interesting to note that the canal was so planned that if electrical transmission had not proven a success, it could be extended for a mile and a half up the river so that the tunnel could be extended beneath it and hydraulic installations could thus draw water from the canal and discharge into the tunnel. This was a wise provision but fortunately it has not been necessary to take advantage of it and no tenant of the Power Co. develops its own hydraulic power except the International Paper Co. whose plant was built before electric power was installed.

Before the commencement of their operations the Niagara Falls Power Co. and Cataract Construction Co. had purchased tracts of land on which their future tenants could locate, such holdings embracing 1581 acres or 2½ square miles, most of which is now within the city limits of Niagara Falls. A part of these holdings were taken over by the Niagara Development Co. for a model town and by the Niagara Junction Railway Co. for a terminal railway to transport raw material and finished products to and from the several factories, connections being planned with all trunk railroads entering the city. The Power Company's property has a river frontage of about two miles and the acquisition of lands under water gives dockage facilities for this entire length. A railway dock was built in 1893 and material can thus be transported by water and the Niagara Junction Railway to the doors of any tenant. Ample land and transportation facilities were thus provided by the company for all factories using their power.

The construction of the tunnel itself was a matter of no small moment even in these days of large numbers, involving as it did the removal of 300,000 tons of excavated material, the use of 16,000,000 bricks and an expenditure of over one million dollars Ground was broken for shaft excavation in September 1890 and the contract for the construction of the first 6700 feet was completed in January 1893. Work was prosecuted from the portal shaft and from two intermediate shafts. The roof of the excavation is secured with timbers for most of its length and it is lined with 16½" of brick work, the height and width inside of brick work being 21 feet and 18 feet 10 inches respectively. The slope of the tunnel is 7 feet in 1000 for 5000 feet and 4 feet in 1000 the remaining distance to the wheelpit. An interesting feature of the tunnel is the steel-lined ogee at the portal, a drop of 10½ feet occuring in a distance of 95 feet. This provision renders the tunnel accessible for inspection to the top of the ogee at all ordinary stages of the lower river. It may be remarked in this connection that on June 1st last all power was shut off from the plant and a thorough inspection was made of the tunnel. The masonry was found to be in perfect condition after seven years of service.

The wheelpit for the first installation was a slot excavated in the solid rock to a depth of 178 feet, the width being 18 feet and length 140 feet. This was completed in 1893 and in 1896 work was commenced on the extension of the pit to a length of 425 feet. The original wheelpit was excavated in the ordinary manner but in the extension the sides were cut from top to bottom with channeling machines, thus preventing the shattering of the rock beyond the desired limits. When the excavation of the extension was nearly complete grave apprehension was caused by a slight inward movement of the wheelpit and fears were expressed that such movement might continue and so ruin the installation made at so great an expense. It is a satisfaction to record that a very careful series of measurements covering a period of nearly six years show that such inward movement has now entirely ceased and it may be confidently stated that it will never occur again, being probably caused in the first instance by the blasting operations in the wheelpit extension.

As before mentioned, the first installation of the Niagara Falls Power Co. consisted of three units and a description of one of these will suffice for all of the machinery in the first wheelpit as the ten units now installed there are practically alike. Water passes to each unit from the canal through a masonry inlet 14 feet wide to the mouth of the steel tube, or penstock, 7′ 6″ diameter, through which it passes down the wheelpit to the wheel case, 141½ feet below the Power House floor. This wheel case is a huge casting about 10 feet in height and 6 feet in diameter and is filled with water under a pressure of 59 lbs. per square inch. The only escape for this water is through openings in the circumference near the top and bottom. The form of these openings is such that water passing through them comes in contact with the wheels placed immediately outside of them at exactly the proper angle to produce the required power. There are thus two wheels attached to each shaft, the water acting on them to produce 5000 H. P. From the above description you will note that the wheels are of the Fourneyron or outward discharge type. The water discharged from the wheels drops into the bottom of the wheelpit and thence goes into the tunnel.

The shaft to which the wheels are attached rises 155 feet to the top of the generator where it connects with the revolving field ring. Suitable bearings are of course provided to preserve the alignment of this shaft.

A very interesting feature is the manner in which the enormous weight of the revolving parts is supported. Consider for a moment a weight of 76 tons revolving at the rate of 250 revolutions per minute. The weight is equal to that of 1000 persons of average size and is moving at an average rate about equal to that of the Empire State Express. You can readily see that it is no slight task to support such a mass. Lignum-vitae, cast iron and steel have been successively recommended for this purpose but in wheelpit No. 1 the great majority of the revolving weight is borne by the same water that drives the wheels. It is difficult to explain this without the aid of a model, but some idea of the principle may be gained when it is said that a hole is cut in the top of the wheel case and into this hole is fitted a disc which connects the wheel to the shaft. This disc is so proportioned that the water in the wheel case acting upward with a pressure of 56 pounds per square inch of disc balances the moving weight.

As the pressure in the wheel case varies with the amount of power developed the revolving weight cannot be exactly balanced at all times, but with the Fourneyrou wheels such unbalanced weight under ordinary circumstances never exceeds 3500 lbs., and this is readily supported by collars placed on the shaft about 15 feet below the power house floor.

For electrical generation it is of course necessary that the speed of the turbines should be kept constant at all times. In order to accomplish this a cylindrical gate is placed on the outside of the wheels, such gate being connected by a series of levers with a governor placed on the power house floor. The gate is thus raised or lowered to correspond to the amount of load on the generator. For example if the machine is fully loaded the gate is raised to its highest position, thus uncovering the entire wheel and allowing the maximum amount of water to escape. If then a customer connected with such dynamo should suddenly throw off 2500 H. P. it would be necessary that the gate should be approximately half closed or one half of the power developed would be used to make the wheel run away. Immediately upon the withdrawal of the half load the governor automatically acts to half close the gate. More than once during the operation of the plant the entire load has been instantly thrown off and the governors have closed the gates without any serious increase in speed. The strength of the revolving parts is so calculated that the speed may be increased 60% without increasing the stress beyond the safe limit. The governors on the first three units were designed by Faesch & Piccard and are purely mechanical in their action. The governors on units 4 to 10 inclusive are electro-mechanical in their action, while those for units 11 to 21 were designed by Escher, Wyes & Co. of Zurich and are operated by oil under high pressure.

To revert to the history of the plant,—the power furnished was so satisfactory and the demand for such power increased so rapidly that on January 22nd 1897 a contract was let for five additional units of 5000 H. P. and on January 25th, 1899 a further contract was made for two additional units, making a total of 50000 H. P. As this amount of power still proved insufficient to serve the purpose of local tenants and of the Buffalo load a still further installation became necessary and the important question arose as to where such additional power should be developed. As the tunnel was originally built with a capacity of 100,000 H. P. the water from the future wheels to the extent of 50,000 H. P. would of course be discharged into the tunnel, but the question was whether additional wheels should be placed in an extension of the first wheelpit or in a new wheelpit placed on the opposite side of the canal. After careful consideration, the latter plan was adopted and on November 3rd, 1899, a contract was let to excavate a new wheelpit 468 feet long, 20 feet wide and about 178 feet deep, an extension of the tunnel, 650 feet long, being made to connect such wheelpit with the old tunnel. The plan adopted has many advantages, among them being the opportunity to build a power house which should embody the results of the experience gained in operating the first power house, the distribution of current between the two sides of the canal, and the added secufity against interruption of service. In other words, the eggs would not all be in one basket. You know Mark Twain says to "place all your eggs in one basket 'and then watch that basket" but in spite of continual watchfulness eggs are sometimes broken. This second wheelpit has now been completed and six 5500 H. P. turbines with their shafting and generators are now installed in it. Five additional units are ordered and their installation has now commenced. By next fall such units will be completed and the Niagara Falls Power Co. will thus have a total of 110,000 electrical H. P. for sale.

The turbines placed in wheelpit No. 2 are of an entirely different type from those in power house No. 1. Only one wheel instead of two is attached to each shaft and the water from the wheel case passes in an inward and downward direction through this wheel, being discharged, not into the air, but through two draft tubes into the water in the bottom of the wheelpit. These wheels were designed by Escher, Wyss & Co. of Zurich, Switzerland.

A very interesting and important test was made on November 19th, 1901 to conclusively determine the carrying capacity of the tunnel and thus prove the correctness of the calculations made in designing such an unprecedented engineering structure. An amount of water was discharged through the wheels, completed and uncompleted, in wheelpits 1 and 2 equal to that which will be required for wheels generating 105,000 H. P. in commercial service and it was found that the tunnel readily discharged this quantity of water.

Time forbids more than a brief reference to that most interesting problem, the manner in which electric power is transmitted to Buffalo. The current from the generators flows to the switchboard where the controlling devices are situated and thence to the largest transformers ever manufactured where the voltage or intensity, of current is raised from 2200 volts to 22,000 volts. It then passes over bare copper wires through the intermediate towns to the terminal house in this city where the voltage is reduced to 2200 volts for local distribution to the various sub-stations. Three separate and distinct transmission lines of three wires are now in use and if any of these lines is interrupted the current can be transmitted on the other two lines. These lines are daily patrolled and constant watchfulness is exercised to prevent such interruption.

But while power development on the American side has thus been advancing by leaps and bounds, the Canadian shores have not escaped the attention of capitalists anxious to utilize a part of Niagara's energy. The material features of the problem there presented are quite similar to those already described, but the business aspects of the case are somewhat different. The Province of Ontario has set aside for park purposes a large tract lying between the upper Suspension Bridge and the Dufferin Islands and in addition control a strip of land 66 feet wide extending from Lake Erie to Lake Ontario. As the works of any water power plant must necessarily cross under or over, or be situated upon such park lands it is evident that all Canadian water power development must be subject to the control of the Park Commissioners and in turn to the Ontario Legislature. It was evident, however, that a power house located in the Queen Victoria Niagara Falls Park whether on the upper or lower river would be much nearer the falls than would be possible on the American side as the State of New York would permit no power development within the boundaries of its property. Being desirous of securing an opportunity for so favorable a development, a number of American and

Canadian capitalists organized the Canadian Niagara Power Co., with the late Albert H. Shaw as President, and on April 7th, 1892 entered into an agreement with the Park Commissioners whereby upon the payment of certain rentals such company was authorized to develop one hundred twenty-five thousand horse power within the park lands in their first power house. This agreement was confirmed by the Ontario Legislature April 8th, 1892 and a charter issued to the company. But in 1892 electrical generation on a large scale was comparatively new and long distance transmission was in its infancy. As a number of the same men were interested in both The Niagara Falls Power Co. and the Canadian Niagara Power Co. they desired to obtain the benefit of the experience to be gained from the American plant before building the costly structure required for their development. Accordingly a new agreement was made with the Park Commissioners July 15th, 1899, and an extension of time secured for the beginning of power development. The plan for utilizing the power is similar in general principles to that of The Niagara Falls Power Co. The power house will be situated at the foot of the slope forming the former river bank and just below the old Carmalite Monastery and south of the Falls View Station. To the power house thus beautifully situated water will be conducted from the rapids by a symmetrically shaped canal spanned by a stone bridge of 5—50 foot arches. The discharge water from the turbines will be conducted to the lower river by a tunnel having the same horse-shoe form as the American tunnel, but four feet greater depth. The most interesting feature of the plant is the size of the units. The original plans contemplated the use of 5000 H. P. machines, but it was found that both the turbine designers and the electrical manufacturers were willing to undertake the building of units of double that size, although nothing of the kind had ever been done successfully. The advantages of the plan are evident as a reduction of nearly 50% is made in the length of the wheelpit, canal, and power house per given amount of power development. The result of the designers skill will be machines of monstrous size. Imagine if you can, a single machine capable of generating 1⅓ times the entire amount of electricity employed for all purposes at the late lamented Pan-American Exposition. A penstock 10′ 2″ diameter conducts the water to a wheel case 13 feet diameter and 14 feet high, discharging water through two Jonval type turbine wheels with draft tubes, the total head being 136 feet. This monster when fully loaded will use four times the quantity of water in a given length of time that is supplied to the entire city of Buffalo from all its enormous pumps. The generator is of the inward revolving field type, revolving 250 revolutions per minute with a peripheral speed of 110 miles per hour, generating current at 12000 volts. The entire weight of the revolving parts of the machine is 251,000 lbs., or about the weight of the bricks in a good-sized dwelling. Such weight will be sustained as in the American turbines by water and oil under heavy pressure. A large amount of work has now been done toward the development above described. The tunnel excavation is practically finished, the wheelpit excavation is nearly completed, the canal is practically dug and a considerable amount of masonry is in place. A contract has been made for five 10,000 H. P. dynamos which are to be built in this country, while three 10,000 H. P. turbines are being manufactured in Zurich, Switzerland, and contract for two more will soon be let. The first installation will thus be 50,000 H. P. but the canal, wheelpit and tunnel are all built for the development of 100,000 H. P. in addition to a reserve unit.

The next company to engage in power development on the Canadian side was the Ontario Power Co. in which Buffalo capital is so largely interested. This company entered into an agreement with the Park Commissioners April 11th, 1900, by which they were given rights for two forms of development. The first method was to bring water through an open canal from the Welland River near its junction with the Niagara River to the top of the high bluff west of the park, where a fall of about 50 feet was available upon wheels in a power house located within the Park at the foot of the bluff. The discharge water was to be at first conducted to the upper river but at a later time to flow in a canal to the high bank of the lower river near the Table Rock House, where it would enter penstocks and there be led to wheels in a power house situated in the gorge on the bank of the lower river. The powers of the Ontario Power Co. have since been increased and its plans have been somewhat changed. A large temporary coffer dam of timber and puddle has been constructed in the upper river near the Dufferin Islands, thus cutting off the flow of water around these islands for the first time in history. While this coffer dam is in place a permanent stone wing dam will be constructed with its top below the surface of the water. The bottom of the river will be dredged and there will be built an entrance forebay with regulating devices from which an underground pipe 18 feet in diameter will be laid to a point just north of the Table Rock House. Provision will be made for three pipes, one of which will supply the first installation. Upon the completion of the head works it is the intention of the Co. to remove the coffer dam and to restore the natural features at the Dufferin Islands to practically their original condition. None of the works of the Ontario Co. will appear above the surface of the ground in the Park proper. The total contemplated installation with water from the upper Niagara is 150,000 H. P. of which 50,000 H. P. will comprise the first installation. One 18 foot penstock will supply water for each installation of 50,000 H. P. Such penstocks will enter a huge brick shaft built below the ground. From this a separate penstock will lead to each of the 10,000 H. P. turbines located in a power house built of native stone in the lower gorge. This power house is planned to have an ultimate length of 1050 feet and a width of 90 feet. The head on the wheels will be 174 feet. Plans still continue for the utilization of power from water to be brought from the Welland River, but these plans will probably not be carried out until the first project is completed. Considerable work has already been done in blasting away the rock for the power house and preparations are completed for active work at the entrance.

A third company has recently entered the field of power development on the Canadian side. This Company, composed of Toronto capitalists and known as the Toronto and Niagara Falls Power Co., have obtained rights for the development of 125,000 H. P. Their plans are not yet worked out in detail but they include in general a power house on the upper river shore supplied with water from a forebay created by building a wing dam into the upper rapids. The wheels will be situated in a wheelpit and water will be discharged by a tunnel at a point beneath the horse shoe falls.

Power development at Niagara Falls, present and proposed, may be summarized as follows:

The Hydraulic Power and Manufacturing Co. have 38,000 H. P. developed, are commencing a power house for 50,000 H. P. additional and can make a total development of 125,000 H. P. The Niagara Falls Power Company have 80,000 H. P. ready for service, are installing 25,000 H. P. additional, which will be completed next fall, and have rights for an additional 125,000 H. P. The Ontario Power Company contemplate using 300,000 H. P. and are at work on the installation of 50,000 H. P. The Toronto and Niagara Falls Power Co. have obtained rights for developing 125,000 H. P. and are commencing the installation of 50,000 H. P. The following are the totals; now developed, 118,000 H. P.; in process of development, 225,000 H. P ; rights secured for 1,150,000 H. P. Please remember that the total water power developed in the United States in 1900 was less than 2,000,000 H. P.

Such is the history of water power utilization at Niagara in the past and its condition at present. But what of the future and of the influence of that future on the prosperity of Buffalo? And by Buffalo we mean the greater Buffalo. Must we leave to our real estate friends all the roseate views of Buffalo future greatness? I think not; I believe that as scientific men and women we may look forward with all confidence to a marvelous growth in our city. That water power generating electricity is to be the power of the 20th century needs but little argument. Wood as a source of heat and power need not be considered and it needs no prophet to foresee the time when the coal mines of the U. S. will be exhausted. Long before that time the price of coal will be so high as to prohibit its use for the generation of large blocks of power. You are all aware of the marked increase in the normal, (not strike), prices of soft coal in the last ten years. The exhaustion of the natural gas fields is so rapid that gas is not a factor in the problem. Look which way we may the inevitable conclusion is that recourse by the great factories must be had to the water powers of the country. Of all the hydraulic developments that the 20th century will witness, which is best situated, which is on the grandest scale, which is most unfailing? Without question that at Niagara Falls. With a reservoir capacity in the Great Lakes of 90,000 square miles, (twice the area of the Empire State), uneffected by the droughts of summer or the freshets of winter, Niagara will stand through the centuries as the emblem of mighty, unfailing, never ceasing power. With this mighty giant delivering the fruits of his labors at her very doors, with unsurpassed railroad facilities, with the iron of Messaba, the copper of Michigan, the grain of Dakota transported by water to her wharves, what city in the world can offer to manufacturing interests such inducements to locate within her boundaries? Buffalo's future greatness rests on no vain product of the imagination but on solid, scientific facts which cannot be belittled or gainsaid, and only the fleeting passage of time brief as the days of a man is needed to make Buffalo the great manufacturing center of the land. The crowning success of her municipal life may not be reached until you and I have ceased the more strenuous labors of life and sit with folded hands in the chimney corner of old age, when the whir of the mighty wheels of her factories falls on our dulled ears, when the vista of Niagara's far reaching activities is seen through our dimmed eyes, but come when it will we will go to the source of all power more content because we have done our little part in developing one of the wonders of the 20th century and adding untold wealth and happiness to the city of our choice. The fable of the rainbow has come true and the shimmering bow that ever spans Niagara's gorge holds at either end the hoarded wealth of the ages which will be poured into the lap of the Queen City of the nation.

(The End.)

BULLETIN
OF THE
BUFFALO SOCIETY OF NATURAL SCIENCES.

Vol. VIII. No. 2.

South Buffalo Floods and Proposed Remedy.

CHARLES M. MORSE,

DEPUTY ENGINEER COMMISSIONER DEPT. OF PUBLIC WORKS, BUFFALO.

It seems to me almost necessary that I present to you some excuse for addressing you on this subject, in view of the fact, that the subject has been very much abused by having been discussed in the daily papers, and otherwise, in such fashion that anything short of an abstract scientific presentation of it here would seem only further aggravation, and I am not prepared to give you anything more than a very general description of the problems involved, and as an excuse for touching on the subject at all, I shall treat it principally on commercial grounds in the general interest of the City of Buffalo.

The hydraulic problems involved have been very carefully studied and all the data and conclusions are in the possession of the Department of Public Works of the city.

The good people of Buffalo have been favored by the newspapers with all sorts of criticisms, wild statements, and attempts to explain natural phenomena in rather unnatural ways, principally in the shape of contributions from regular subscribers, taxpayers, alleged public benefactors, etc., but I have not noticed very much in the way of honest efforts on the part of the newspapers to inform the public of the actual situation, which might be done by a little careful collecting of available facts and figures. On that account, I think it may be well for me to present what I know of the situation in such shape that it may reach some of the thinking public, and probably this is the best place to find that part of the public.

Up to a quite recent date, apparently what data had been secured, that might be of use in discussing a remedy for the troubles experienced, had not been put into tangible shape for use, but now the problems at issue are practically solved and the subject is very clearly understood.

To state the subject, I would say the Buffalo River flows within the city limits through an alluvial valley which at times is overflowed by the waters of the stream because they are in excess of the carrying capacity of the channel, or are forced out of the channel by temporary obstructions.

The area within the city that is flooded is a varying amount, reaching a maximum of about 1600 acres. No two floods cover exactly the same bounds.

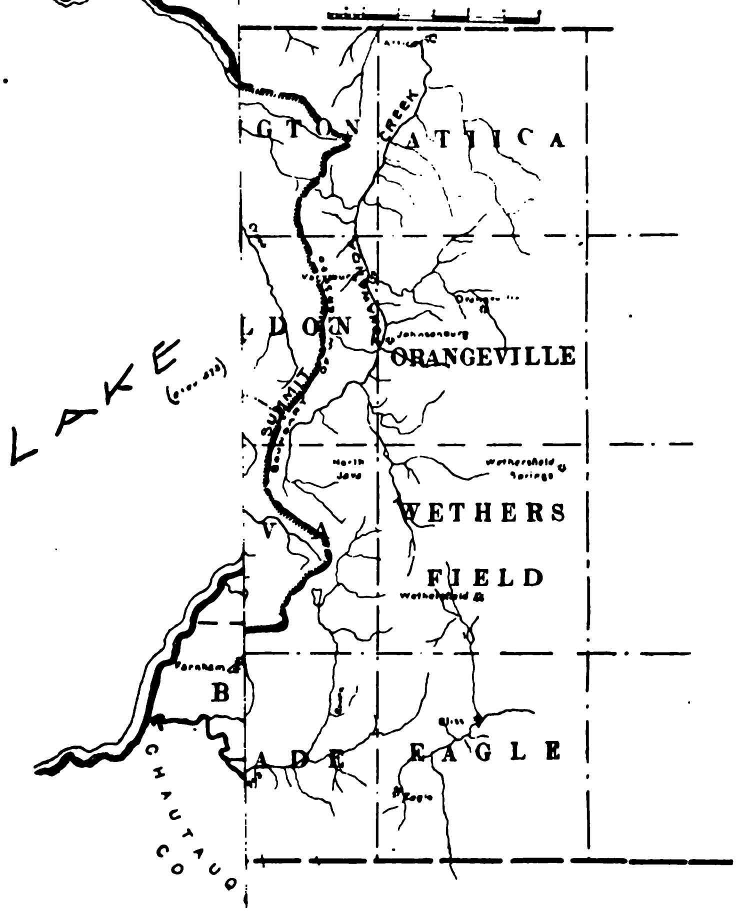
The population of the area flooded is about 10,500 and the assessed valuation of the lands is about $5,000,000. The value of this section of the City of Buffalo seems to be defined by the flood conditions.

The location of this area would naturally tend to make it a very valuable part of the city except for this one serious drawback.

Considering it simply as a residence section and making a rough calculation of the cost of the floods on very conservative lines; let us assume that a flood costs the average resident at least one day's wages, or $3 00—(he is generally detained from his work by the flood:) the damage to provisions and premises $1.50, and the cost of cleaning up $1.50, or a total of $6.00. $6.00 is the annual value of $100 00. The actual immediate value of the area flooded—1600 acres, would therefore be increased by abatement of the flood $100 per average building lot, or $1000 per acre, a total of $1,600,000. 1000 acres of land lying beyond the flooded area has its access to the city cut off by each flood, or at least one day per year, which costs at least $3.00 per building lot—the annual value at 6% of $50, or $500 per acre, or for the 1000 acres a total of $500,000. This gives a total of $2,100,000 as a conservative estimate of the increased valuation that would result by abating the floods; that is, one flood per year, and there are more.

The increased valuation of property for manufacturing industries, which are now practically barred by the existing conditions, might be estimated in the same way at a very large amount, but the above figures will easily indicate to any business man that an expense of $2,100,000 would be a very reason-

MAP
OF PART OF
ERIE AND WYOMING COUNTIES
SHOWING THE WATERSHED
OF
FFALO RIVER AND CAZENOVIA CREEK
SCALE 1 IN = 2½ MILES



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able proposition and would be a profitable investment by the city.

About two miles inside of the city line and six and three-quarter miles above the outlet of the Buffalo River it is joined by Cazenovia Creek. These two streams, with their tributaries, drain a watershed of approximately 413 sq. miles.

The map shown, herewith, gives a fair idea of the country drained. (Cut 1.)

The distance from the headwaters of Buffalo River to its outlet in Lake Erie is approximately 50 miles. About 6¾ miles above its outlet, it is joined by the Cazenovia Creek, whose total length is about 26 miles ; about 10 miles from the outlet of the Buffalo River it is joined by Cayuga Creek, whose length is about 39 miles.

The watersheds of these different streams are approximately as follows:

Buffalo River proper,	145 sq. miles
Cayuga Creek,	127 sq. miles
Cazenovia Creek,	87 sq. miles
Branch Cazenovia Creek,	54 sq. miles

making a total of 413 sq. miles of territory which contributes to the waters of the Buffalo River below its junction with Cazenovia Creek.

From the report submitted by Mr. Rudolph Herring to the Board of Public Works, under date of July 24th, 1899, I have taken the following statement of flood conditions:

	Watershed Sq. Miles	Total Max. flow cu. ft. per sec.	Rate in cu. ft. per sec. per sq. mile
Buffalo River above Junction with Cazenovia Creek,	272	17000	62.5
Cazenovia Creek,	141	8000	56.7
Buffalo River below junction,	413	23000	55.7

From later measurements I learn that the total flow is under stated, for maximum flood conditions.

A comparison with other streams subject to similar freshet conditions is interesting and I am able to quote the following figures from observations on such streams:—

	Watershed Sq. Miles.	Total Max. flow cu. ft. per sec.	Rate in cu. ft. per sec. per sq. mile.
Perkiomen River, Pa.,	152	10518	69.2
Croton, N. Y.,	339	25300	74.9
Ramapo, N. J.,	160	10540	66.1
Falls Creek, N. Y ,	117	4800	41

Apparently the statement of flood flow for the Buffalo River below the junction with Cazenovia Creek is less than for the Croton River with a somewhat smaller watershed. This is not inconsistent in the light of known conditions. Heavy rain storms are greater and produce greater floods on the Atlantic slope of the Alleghany Mountains than on the western slope. The same may be noted of the Perkiomen and Ramapo floods.

The flood of February 9th, 1900, reached a very high stage in the lower portion of the Buffalo River, due to a westerly gale, together with an ice and boat jam. The estimated discharge of this flood was but 18000 cu. ft. per second, and the high water in the lower river was evidently due to the peculiar conditions noted.

On February 28th and March 1st, 1902, there appeared a flood which produced the largest measured discharge, and reached the highest recorded general level of overflow on the upper parts of the streams within the city limits. The actual measurements of flow in the channel gave a total of 24300 cu. ft. per second.

It is the custom to establish observers at several different points when floods are expected and generally it is easy to predict a flood from 5 to 20 hours before it arrives at the city line. This last flood came a little sooner than was expected, and some of the observers were not aware of the conditions until the morning of March 1st: however, two fairly continuous sets of gauge readings—one at the head of navigation and the other near the center of the flooded area, at the junction of the Buffalo River and Cazenovia Creek, were obtained, which, with the records of the United States Engineer's recording gauge near the mouth of the river, give a very fair idea of what occurred.

The slope of this flood and others is shown upon the accompanying diagram of flood heights.

These records of gauge readings, together with float tests made at different points on the stream, where fairly accurate measurements of channel capacity can be made, enabled us to estimate the amount of flow of water under different flood conditions.

Measurements of the channel before and after floods have enabled us to determine, with some degree of accuracy, the effects of the floods in the matter of deposit in the river bottom

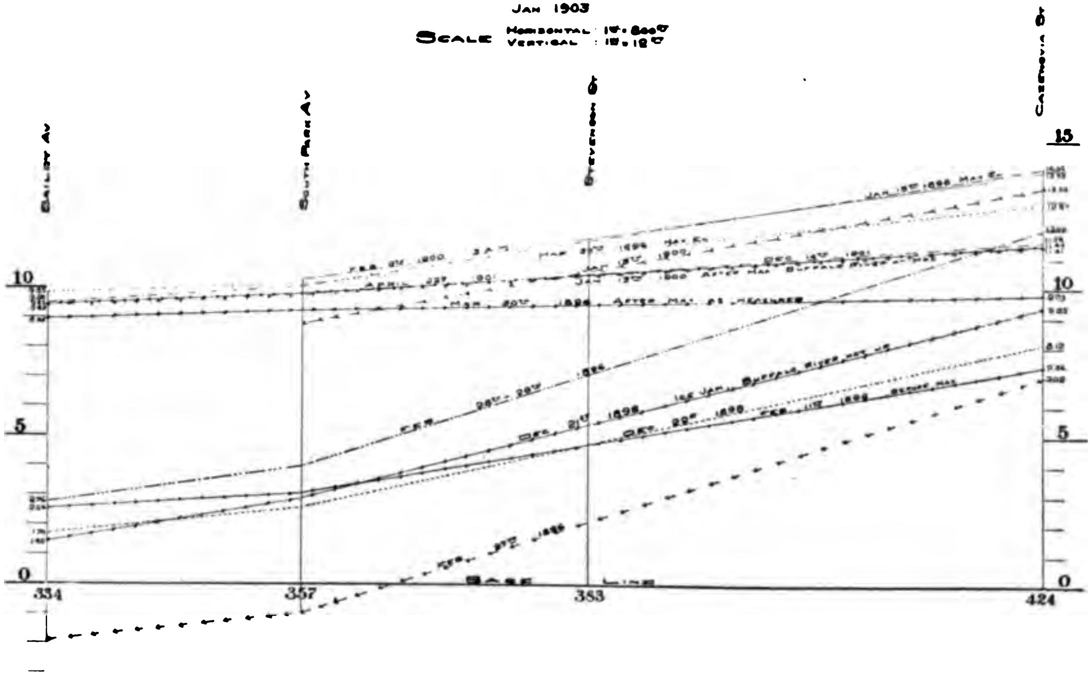
FLOOD HEIGHTS
CAZENOVIA CREEK.

FROM 896 TO 1902

HEIGHTS SHOWN AT VARIOUS POINTS EXCEPT AS NOTED

BUREAU ENGINEERING
BUFFALO, N. Y.
JAN 1903

SCALE HORIZONTAL : 1" = 800 FT
VERTICAL : 1" = 12 FT



of silt, and also to determine the scouring and eroding effect of the current.

The accompanying profile of the bottom of the river, together with the flood profiles showing the slope of the surface of the water, give a graphic illustration of the action of the several floods of which we have records. (Cut 2.)

Referring to the map of the city:—the valley of the Buffalo River once entered Lake Erie south of the Tifft Farm, but probably the action of the shore currents of the lake forced the outlet of the river further north until the stream was forced upon a rocky ledge at Louisiana Street and near the outlet. This acted as a barrier and caused floods upon the lower portion of the stream.

Within the past thirty-five years some half a million dollars have been expended between the Erie Railroad freight house and Hamburg Street for deepening and improving the channel through the rock, and this work has prevented the recurrence of floods which formerly occured in that locality, by providing an adequate channel for the passage of the water. This fact will be referred to later as bearing upon the proposed method of abating the floods.

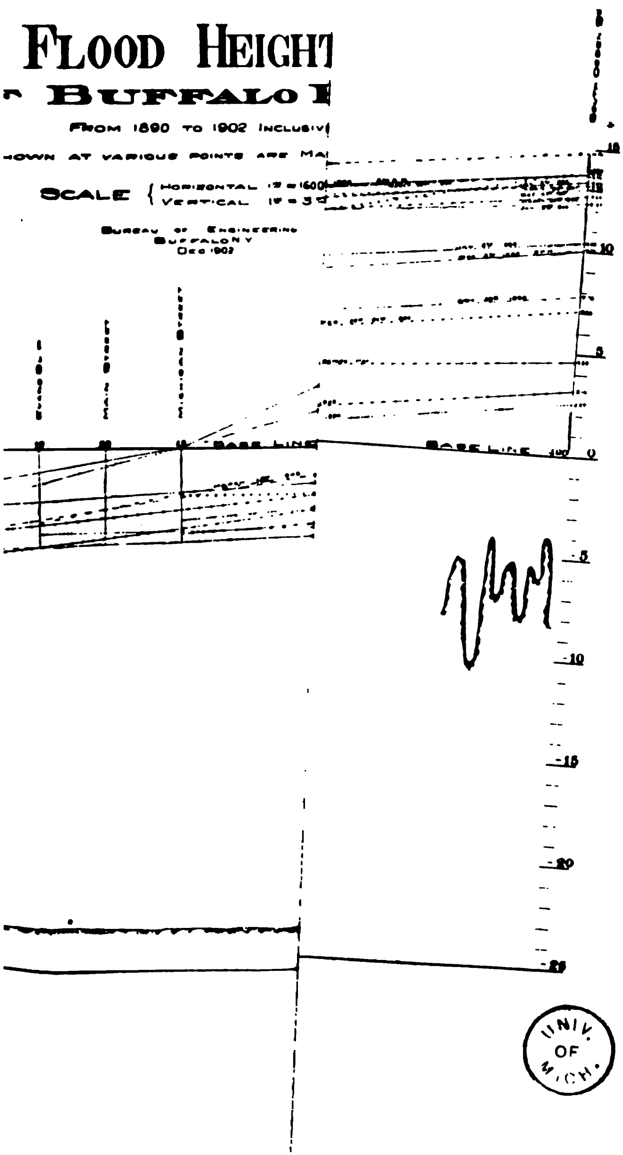
The present conditions inside the city limits, and in the section of the city known as "South Buffalo", are as follows:—

At irregular intervals—at least twice or three times each year, the banks of the Buffalo River and of the Cazenovia Creek inside of the city (we will not consider the conditions outside of the city line) are overflowed by the sudden melting of snows, or by heavy rains on the upper reaches of the streams, and an area of about 1600 acres is for a short time under water. The floods do not always reach the same defined limits of area, but about that amount of territory is subject to disastrous flooding.

The usual programme is about as follows :

A heavy continued rain when the ground is frozen, or previously saturated, as for example, the flood of May 20th, 1894, and that of July, 1902. More often the flood conditions are produced from melting snow, or a combination of such with rain, or even thunder storms, as that of Jan. 29th and 30th, 1903.

The summit of the flood wave usually follows the crest of the storm, or greatest run-off in melting snows, by about 12 hours, the maximum flow in Cazenovia Creek occurring from three to six hours before that in the Buffalo River. The usual statement in the news items to the effect that the flood was en-



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Assuming these figures ve they are nearly, this would indicate the largest flood of which we have record, no other flood of nearly as large measured discharge having occured in 8 years.

the storm, or shows, by about hours, the maximum flow in Cazenovia Creek occurring from three to six hours before that in the Buffalo River. The usual statement in the news items to the effect that the flood was entirely unexpected is as accurate as the statement that "this is the worst flood ever experienced in South Buffalo." We have them every year at about the same times.

I am able to show here a few illustrations of the effects of these annual occurrences in South Buffalo.

During the ordinary stages of the Buffalo River it crosses the city line in a small channel and is apparently very insignificant. In the case of high floods, it crosses that line in a stream about 3000 ft. wide on the surface and sweeps over South Buffalo at a nearly constant width, interspersed, however, with high points, railroad embankments, bridge abutments, etc.

From observations and measurements made March 1st, 1902, it was determined that the channel of the lower Buffalo River was called upon to carry a flow of 25,000 cu. ft. per second. This flood was coincident with other unusual floods in this section. It was caused by the melting of a heavy body of snow which had been on the ground for some time. The run off began as soon as the waters began to cut their way through the hard snow. It seems probable that the conditions favored a flow of longer duration than usual and that Cazenovia Creek, while reaching its maximum three or four hours earlier than Buffalo River, held such maximum flow until the latter also reached its maximum. If this be true, then deductions made from former measurements and observations, that the respective maximum discharges were 8000 and 17,000 cu. ft. per second for the two streams seem to be verified.

Another element entering into the estimate of discharge from measurements on the lower section of the river in 1902, is the fact, that at that time about 1600 acres (the largest area of which we have record) was overflowed within the city. This represents storage at about the maximum discharge.

A rough measurement of the contour of the country overflowed, gives a total storage within the city of 161,172,000 cu. ft., equivalent to 1 hr. 47 min discharge of the stream at the above stated maximum of 25,000 cu. ft. per second, and this amount of storage in the time stated would indicate a maximum entry of water into the city of 29,800 cu. ft. per second, or an increase over measured amount of flow in the channel of 18%. Assuming these figures to be correct, which I believe they are nearly, this would indicate the largest flood of which we have record, no other flood of nearly as large measured discharge having occured in 8 years.

The minimum discharge of the Buffalo River below the junction with Cazenovia Creek is about 60 cu. ft. a second. The maximum discharge in full flood is about 25,000 cu. ft per second.

I think the foregoing statements can be taken as fairly representing the existing conditions and as indicating the necessity for some action to remedy the disastrous effects. The remedies that have been suggested are several and I will endeavor to explain the result of the studies of the subject. The subject has been intelligently studied with a view to the desired remedies by no one apparently except the city authorities with the application of a technical knowledge of the hydraulic problems involved.

The means of preventing the overflow may be classed as follows:

First: The storage of flood flow outside of the city so that the waters may be held back and discharged at no greater rate than will be cared for by the natural channel of the river.

Second: The diversion of the waters to some other outlet outside of the city.

Third: The raising of the entire territory affected above the flood level.

Fourth: Providing an adequate channel within the city.

The first suggestion—that of storage outside of the city is subject to the following conditions:—If storage is to regulate the flow to a certain maximum amount, the controlling works must provide for a free passage of all waters without storage up to the carrying capacity of the stream and hold back all in excess of that amount. This condition would demand an expensive and complicated construction. In the flood of March 1st, 1902, to have prevented the overflow of the city streets a storage capacity of at least 22,000 acre feet would have been necessary—that is, it would have required a reservoir covering 1000 acres, with a depth of 22 ft., to have stored the amount of water which overflowed the section of the city flooded. This would be a lake ½ mile wide, 3 miles long, and deep enough to float any lake craft. Such a proposition would require the acquisition of a large area of land and probably of very valuable agricultural lands, the reconstruction of road bridges, and possibly railroad beds. Such reservoir should at all times of low water be empty, that it may be in readiness for the floods when they come, and it would be a nuisance

Furthermore, the locations of the several streams and the natural lay of the country would apparently require storage reservoirs on three different streams—Cazenovia Creek, Buffalo River and Cayuga Creek.

Considering the second proposition—the diversion to some other outlet outside of the city, there does not seem to be any safe place for such diversion, except that Cazenovia Creek might be diverted into Smokes Creek.

To illustrate the value of such diversion, it may be stated, that should the entire stream be diverted into Smokes Creek, it would not prevent the present troubles. The maximum freshet discharge of Cazenovia Creek is not over 8000 cu. ft., and in ordinary flood it would not exceed 5000. Possibly that 5000 cu. ft. of flow might be diverted into Smokes Creek and so made to overflow a small stream which already has a bad name as a flood maker along its own course and would seriously damage large interests now located at its outlet. The most recent flood of which we have record caused considerable damage at the outlet of Smokes Creek.

Furthermore, the records show that the maximum flow in Cazenovia Creek in case of a freshet occurs several hours previous to the maximum flow in Buffalo River, and usually the Cazenovia Creek flood has commenced to subside before the Buffalo River flood reaches its maximum. Such diversion would be expensive. Different estimates of the cost vary all the way from $250,000 to $600,000, and do not give any accurate information as to probable land damages. The suggestion does not seem worth considering.

The third suggestion—that of raising the level of the entire territory affected, would certainly remedy the trouble, but to raise the level of the improvements now housing over 10,000 people, as well as many miles of improved streets, would not prevent flooding of cellars unless carried to an extreme extent.

The sewage of South Buffalo discharges into Cazenovia Creek and Buffalo River and the discharge of the sewers is naturally affected by the height in water of those streams. Filling for the purpose of raising the level of this territory is not easily obtained in that section. The amount necessary to fill the space occupied by the overflow waters of 1902 would be about six million cubic yards. That suggestion does not seem worth considering.

The fourth plan mentioned—that of providing an adequate channel within the city seems to be the only feasible as well as efficient method of handling the proposition.

With this proposition in view extensive surveys and measurements were made and after much figuring and arguing, a sort of a compromise plan was adopted by the Board of Public Works and the work of widening and deepening the channels of Buffalo River and Cazenovia Creek on present lines was advertised in 1900 and bids received. The bids were reported to the Common Council and referred to a committee, where I believe they still are.

I refer to this as a compromise plan, because the engineers employed to criticise it, as well as the engineers who designed it, apparently agreed that quite radical changes of the channel in the shape of short cuts across country would be better, but that the present channel was the line of the least resistance in the matter of property damages. It was also considered to be less expensive than would be the building of a straighter channel, but that must have been due to the failure to obtain estimates from the engineers employed.

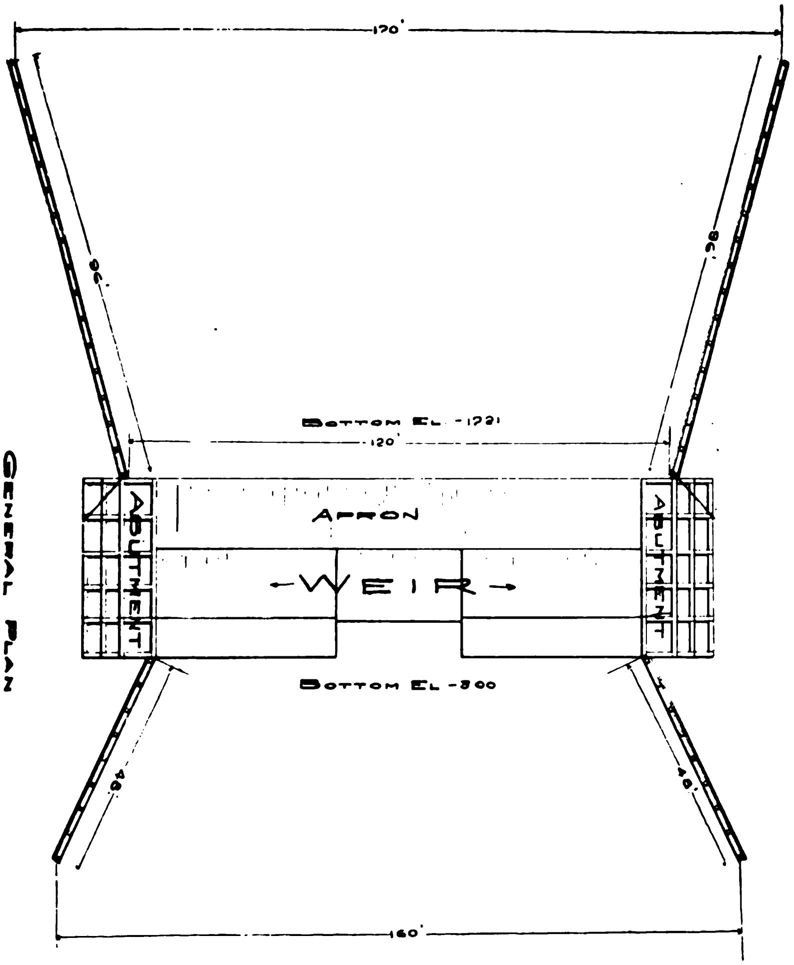
The asserted great cost of straightening the channel, due to the necessity of providing new railroad bridges is not a charge upon the people of the territory benefitted nor upon the city—The Buffalo River within the city limits is, according to the laws of the state of New York, a navigable stream and is recognized as such by the United States authorities—as such, it is subject to the Federal laws in the matter of crossings—Such crossings are an individual charge upon those enjoying the privilege.

The cost of necessary extension of sewers and construction of new outlets will be about $19,000.00.

In April, 1902, a preliminary plan for straightening, widening and deepening the channels within the city limits and a cut-off, or additional discharge into the lake, or what is now known as the outer harbor on account of the new breakwater construction, from a point about 10,800 feet from the present outlet of the river was approved by the Commissioner of Public Works and submitted to the Common Council. By order of the Common Council, a survey was made, and the work in accordance with this plan carefully laid out and estimated.

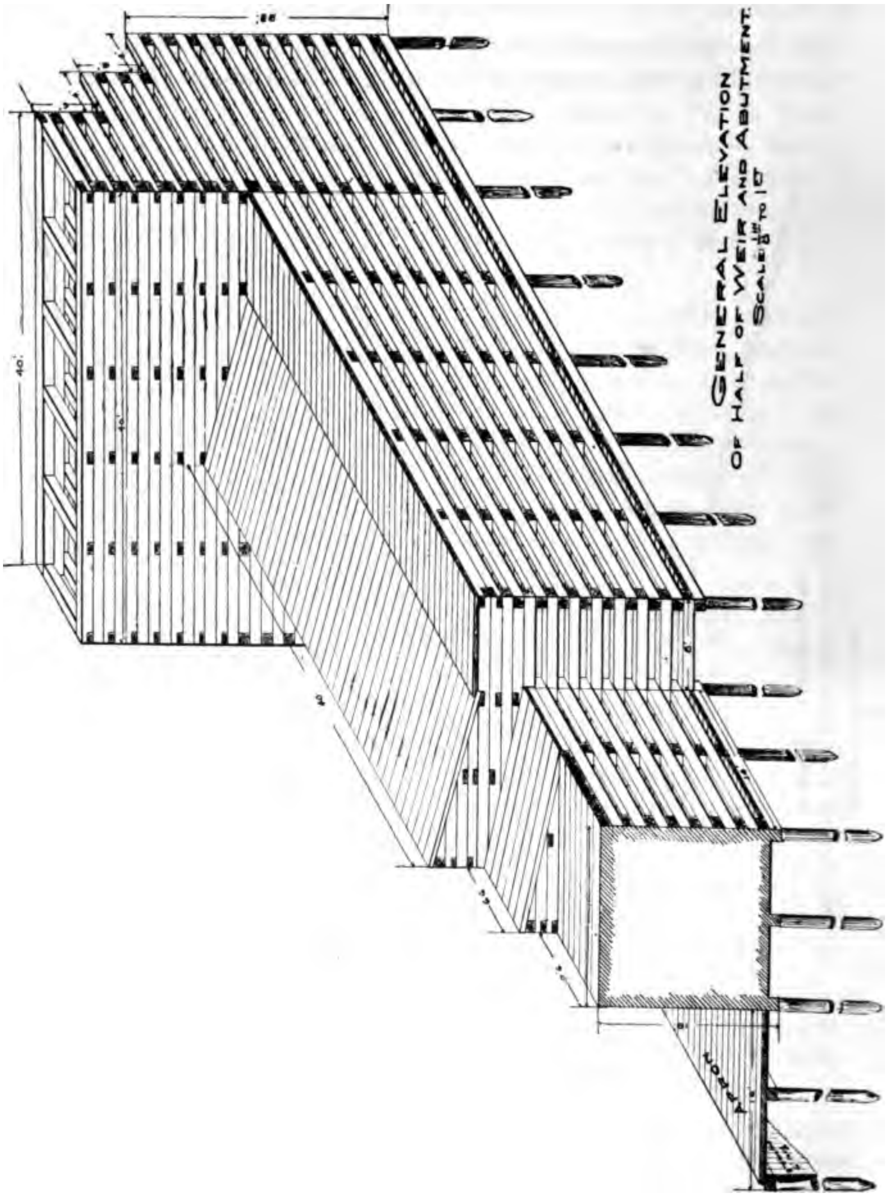
Bids were received for the excavation of this proposed new line on the 24th of February of this year. The work which it is proposed to do, I will endeavor to describe.

At the city line on the Buffalo River there will be constructed a controlling weir consisting of rock filled timber crib work founded on piles, together with wings above and below and an earth fill along the city line from such weir to the Mineral Springs Road.



GENERAL PLAN
OF WEIR, ABUTMENTS AND WINGS.
Scale [illegible]

I am able to show you drawings of the weir construction, which I think quite clearly explain it.



General Elevation
of Half of Weir and Abutment.
Scale ⅛ in to 1 ft

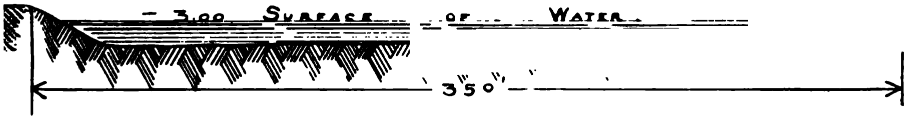
TYPICAL SECTIONS.

OLD CHANNEL

SCALE: 1 IN = 50 FT

BUREAU OF ENGINEERING

BUFFALO N.Y.



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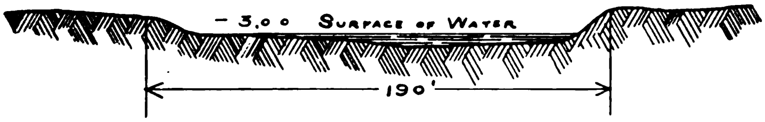

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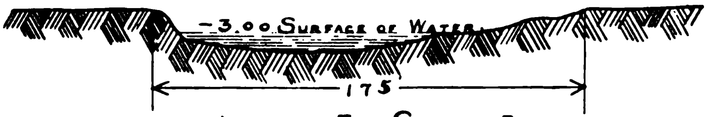

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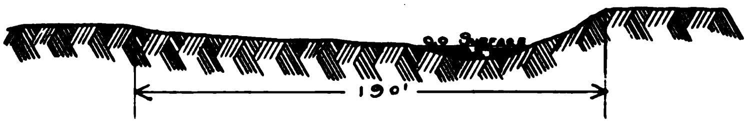

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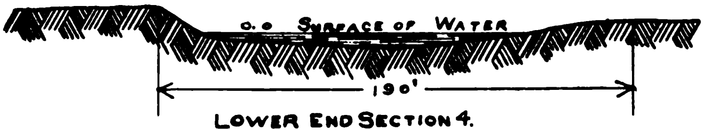

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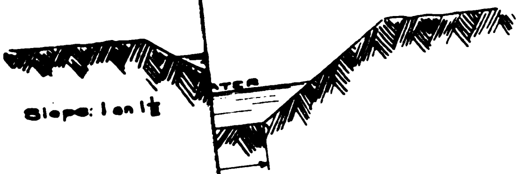

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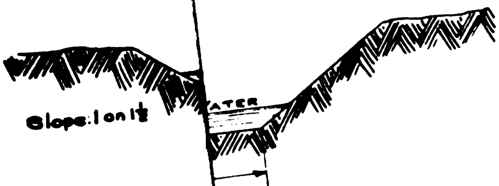

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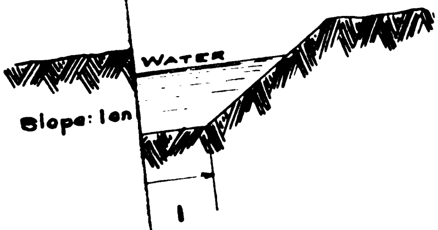

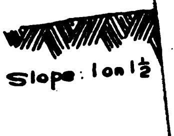

The object of this construction is twofold, First: to collect all the waters of the stream in the channel to be provided below the weir. Second: To maintain the present flood conditions outside of the city in order to avoid any possible complications with other than city authorities. It may be stated right here that it is generally considered that a flood over such a valley as that of the Buffalo River, when the land is utilized for market garden purposes is not always an unmixed evil. A large portion of the territory inside of the city line, which is now made to suffer injury by the floods, was a few years ago cultivated and the soil probably much enriched by the annual floods. Anyway, it is concluded that the city authorities should confine their work to the territory controlled by them and it is even, with justice, I think, argued that the controlling works proposed at the city line should be paid for by the state authorities—the same being a work made necessary by waters furnished in superabundance by lands extending many miles beyond the city line and subject to the control of the state authorities.

From below the controlling weir a channel is to be excavated in the earth with a width on the bottom of 120 ft. and with banks sloping in a ratio of 1 to 1½—the elevation of the bottom of this channel being at the upper end—17 feet below city datum; this channel to be continued to the junction with Cazenovia Creek—a distance of 7600 feet, the elevation of the bottom at such junction being—21 feet (the diagrams, herwith, show section of the proposed channel and of the present channel) (Cuts 5, 6)

At Cazenovia St. on the Cazenovia Creek there is at present a dam which holds the waters back in an artificial lake in Cazenovia Park. This stream at this location is on a rock bottom and just below Cazenovia Street it is proposed to start a channel excavated in the rock to a depth of about 12 feet to the proposed channel bottom at an elevation of—9 feet city datum. This channel to be 75 ft. wide on bottom and of section as shown by the accompanying diagram. On another sheet, I have shown a section of the present channel of this stream. This section of channel proposed is continued to the junction with Buffalo River. From the junction of Cazenovia Creek with Buffalo River a channel is to be excavated 170 feet wide on the bottom, with sloping banks as shown by diagram of said channel and continued to the point of proposed outlet into the outer harbor, at which point the bottom is at an elevation of —23 ft. From this point, as indicated on the map, about opposite what is known as Farmers' Point, the channel is to be excavated in the sand and soft blue clay there existing across the narrow neck to the shore of the lake and carried out by pier protection to a depth of water of 18 ft.

The accompanying diagram shows a cross section of this channel.

The principal reason for the construction of the new outlet to the lake is because of the occasional uncertain conditions of the present outlet as to its ability to carry off the flood waters in case of ice and boat jams. Ice passing out of the mouth of the river is uncertain. With no wind, or with any but a southwest wind it is possible to keep an outlet open for the ice to reach the open waters at the head of Niagara River. With a strong southwest wind the broken ice around the mouth of the river is driven in and at once closes any outlet channel which may exist.

The effect of the new breakwater and improved channel towards Black Rock Harbor are as yet undetermined quantities.

The effects of gales on ice obstructions in the lower portion of the river are of as much concern to that portion as to the flooded area. The lower portion of the river will always remain an unsatisfactory outlet for large discharges of water and ice. It is obstructed by bridges and by many vessels moored along its frontage.

The separate outlet to the lake, as proposed, seems absolutely necessary to the proper and sure attaining of the desired object.

In studying the records of floods and flood results on the Buffalo River, I note that on February 9th, 1900, several large vessels on the lower river broke from their moorings, doing much damage to themselves and to bridges, and afterwards, with the flowing ice forming an obstruction which produced the highest flood elevation of years along the lower portion of the unimproved river.

A study of the situation seems to lead to the conclusion that such disasters cannot well be prevented if no other outlet than the present one is provided. This outlet entering the protected area inside of the outer breakwater might not be able to dispose of any large amount of flowing ice, as it will probably jam up against the heavy ice in the outer harbor, but even when completely jammed with ice, it will provide a partial outlet for flood flow and lessen the danger of floods from back water caused by obstructions in the old channel.

The fact that this new outlet is located some 10,800 ft. above the present outlet, and the new outlet being at the same level as the old, will necessarily increase the flood slope of the water by shortening the length of the flow from the city line to the lake. Without this outlet a rise of 4 ft. in the lake level will produce a rise at the junction with Cazenovia Creek—a distance of 24,600 ft. measured on the stream, of 2 1-10 ft. With the proposed cut-off to the lake, the same rise in lake level would produce a rise of only about 1.65 ft. at the junction.

The new channels proposed are all based on assumed maximum discharge of the Buffalo River of 25,000 cu. ft. per second, and a velocity of 5 ft. per second. This total discharge is a safe maximum, it probably being very nearly attained at least once a year, and is very seldom, if ever, exceeded.

The velocity of 5 ft. per second is considered safe for the banks, as proposed, inasmuch as it cannot exist but for a few hours in maximum flood, and at all other times is very much less.

I think that further details, such as bank protection, which is necessary at different points, bridge abutments, etc., would not be of especial interest in this connection and I will omit all that and refer anyone who is especially interested in the problem to the specifications prepared for the work by the Bureau of Engineering of the Department of Public Works, and to the very full report on the hydraulic problems involved, presented to the New York State Water Storage Commission by the local committee appointed by such commission and requested to present a study of the situation.

As a suggestion of the value of the proposed improvement beyond that suggested in the fore part of this talk, I would state, that before the location of the Lackawanna Steel Co's. plant just beyond the city line on the lake shore, land along the Ridge Road, which runs from the lake, parallel to the city line and just beyond it, sold for $300 per acre, or $1.00 per foot front on said Ridge Road. Since the location of the Steel Plant, land on this road has been selling for from $100 to $150 per foot front, or $30,000 per acre. Figuring an acre as having 300 ft. frontage, the average value of the land in this territory is now $5,000 per acre as against $300 three years ago.

With all of South Buffalo relieved from the inroads of Buffalo River and Cazenovia Creek and equipped with proper drainage, which would then be possible, and also with several miles of available water front on the improved river, there would undoubtedly be as great an increase in values, for there would be no better location for manufacturing sites in or near the city.

That the work of abating the floods will go ahead in the near future seems to be assured by the earnestness of the people most seriously affected and those who will profit by the improvement.

The bids now before the Common Council and the report of the Commissioner of Public Works give assurance that the necessary work can be done at a cost that will not exceed the amount now available for the purpose.

The plans and specifications have been filed with the Chief of Engineers of the United States Army and are approved by the Secretary of War—Such approval is necessary for authority to change the alignment of the Buffalo River as proposed, the same being a navigable stream and, as such, under the jurisdiction of the Federal authorities.

C. M. MORSE.

Buffalo, N. Y.,
April 3, 1903.

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OF THE
BUFFALO SOCIETY OF NATURAL SCIENCES.

VOL. VIII. No. 3.

ECONOMIC ZOÖLOGY.

READ BEFORE THE BUFFALO SOCIETY OF NATURAL SCIENCES,
APRIL 10, 1903.

BY FRANKLIN W. BARROWS, M. D.

Some one has said that economic zoölogy is the study of animals from the standpoint of dollars and cents. It is this and more; for it includes the consideration of all the influences exerted by animals for the good or the ill of man, their reputed master. The object of the science, or perhaps it should be called the art, is the complete realization of our dominion over animals. The literature of the subject is found scattered through the reports of the various scientific departments of all governments. Probably a very fair idea of the present state of the subject can be obtained by consulting the reports of our own government.

Of the actual beginnings of economic zoölogy we know absolutely nothing. There is considerable evidence that the cave-dwellers used a variety of animals, including fishes, for food, but there is nothing to show that these primitive folk had established friendly relations with any of their animal neighbors. They clothed themselves in the skins of beasts and made rude tools from bones and horns, but it was evidently reserved for a later race to begin that long campaign of education which has given to us our domestic animals. With the taming and controlling of the lower animals man himself progressed from barbarism to civilization, and it may safely be assumed today that the culture of a race is in direct proportion to their progress in the utilization and mastery of the animal world. In our brief consideration of man's present attainments along this line, it will be well to speak first of his mastery of domestic animals and then, of his dominion over untamed animals.

We know that the most familiar animals of the house and farm were first subjected to man somewhere on the Asiatic continent, but their origin and the date of their subjection are, in practically every case, mysteries beyond the power of the historian to solve. Certain it is, however, that man early acquired the art of improving the primitive stock by selective breeding, and thus began to develop under his own guidance the many varieties of breeds and strains that obtain today among all our domestic animals. Thus the exceedingly diverse varieties of pigeons, dogs, horses, cattle, etc., are the results of human design slowly and deliberately worked out in accordance with natural laws. Many of these varieties, such as the pouters, tumblers and fantails, among pigeons, and the poodles and bull-terriers among dogs, have been bred merely to suit the caprice of the fancier. In the majority of cases, however, the motive of the breeder has been purely economic and we of this century are literally "the heirs of all the ages" in our possession of so large a group of animal species won from their native state and developed to supply so perfectly so many of our needs. The dog has been adapted to the requirements of hunting, herding, policing, drawing burdens, and even of serving as the companion of man. Other animals have been bred for hunting and fishing—such as the ferrets, otters, cormorants, owls and falcons. Fifty years ago there were a half dozen breeds of chickens in the United States. Now there are over 100. At the same time the yearly number of eggs per hen has been increased from seventy-five to one hundred and seventy-five, according to Prof. G. P. Roberts, of Cornell University. The poultry breeder has produced varieties excelling also in quantity and quality of flesh and plumage, respectively, while he has utterly conquered the migratory instinct which was so strong in the original stock of our ducks, geese, and other fowls. The domestic pig weighs four times as much as his wild relative, and has developed remarkable qualities of mind and body from his association with man. Among wild cattle the female produces just enough milk to suckle her calf, while the domestic breeds most famous as "milkers"—the Holsteins and Ayrshires—will yield their own weight in milk every twenty or thirty days. Both the quality of the milk and the period of lactation have also been immensely influenced by breeding. Other varieties of cattle, as the Durhams and Herefords, are bred for beef, while the Devons are noted for their excellent qualities as yoke oxen. Our modern horses, also, illustrate in many ways the art of the breeder. Originally serving man as a pack animal, the horse soon became the indispensable companion of the traveler and the merchant, and in course of time acquired a place of inestimable importance in warfare. The steed of the Norman knight was the noblest horse that the world had ever seen, and from him are descended the finest draught animals of the present day. Neither the Norman knight, however, or any of his contemporaries ever dreamed of the excitement of the modern race track, or fancied that the prize horses of the Derby would win their laurels by whisking a light-weight jockey around the circle in a ball-bearing sulky, and not, forsooth, by carrying a lusty baron and two hundredweight of armor in the tournament. Both in England and in this country the most careful attention has been given to increasing the speed of the horse. Seventy-five years ago the running record was three minutes. In 1865 Legal Tender ran in 1:44, a record that is equalled or excelled on every race-course in the country today. In 1843 a trotting record of 2:30 was established. In 1894, fifty years later, the number of horses on record that had trotted a mile in 2:30 or less was over 7,500, and rapidly increasing. Twenty-three horses at this date had records ranging from 2:04 (Nancy Hanks) to 2:10. Thus within the past century the American horsemen have developed a distinct breed of horses, and all by the persevering application of the principles of artificial selection for four or five successive generations. At the same time, we have not neglected the perpetuation and improvement of other serviceable breeds of horses, adapted to the plow and the road. The mule, a hybrid that owes its existence to the enterprise of the stock-breeder, is one of our national resources, and St. Louis has the proud distinction of being the greatest market on earth for this animal.

While the present is an era of great accomplishments in the improvement of domestic animals, it must be admitted that few if any new species are being won from the wild state in this or other countries. The list of domestic animals remains about what it was two centuries or more ago; in fact, the falcon and other species that were once so generally employed in the sport of "hawking" have been allowed to return to the wilderness—the only case, according to Shaler, in which man has abandoned a species once domesticated. It is said that the camel is gradually retiring from active service for man, but it is not likely to be entirely superseded for many years to come. Even the horse and the dog are of less economic importance now than when they helped man to explore and colonize the vast wilderness of a few generations ago.

If our progress in the arts and industries has somewhat depreciated the value of a few of our domestic animals it has more than compensated for this depreciation by discovering new uses for animal products and thus vastly extending the utility of the animal kingdom as a whole. This age excels all others in the variety and extent of the services derived from animals. No animal product is wasted. Indeed, every item in the inventory has its market value today. It is not surprising, therefore, that the agricultural world devotes its best efforts to the problems of livestock. Our experiment stations in this and foreign countries, are investigating the food of farm animals in order to discover the proper dietary for the work-horse, the milch-cow, the porker, or the laying-hen. The agricultural chemist is studying the effect of different diets on the quality of manures produced and utilized on the farm. The Bureau of Animal Industries, an indispensable adjunct to the other activities of our United States Department of Agriculture, is investigating the vast field of diseases of domestic animals and experimenting on the means of preventing or curing them. Results of momentous significance have been attained in the study of trichina, Texas fever, hog cholera, tuberculosis, sheep-scab, tapeworms of poultry, and a host of other parasitic and infectious diseases which constantly prey upon our useful animals. It would be interesting to recount a few of the methods used and the results obtained in these investigations, if the limits of this paper would allow. Suffice it to say that the means employed and the money expended in these researches have been amply justified by the results, not only in our own land, but the world over.

Twenty years ago the British kingdom was losing a million sheep annually from the disease called "liver-rot," and in the years 1879-80 the loss was over three million. The investigations of the royal commission charged with the study of this disease showed that it was due to a parasitic worm, and pointed the way to remedial measures that have materially reduced the pest and restored to England millions of dollars. A few years ago the British public became aroused on the importance of checking tuberculosis in cattle. A test of Queen Victoria's herd at Windsor Castle showed that ninety per cent of the animals were afflicted with the disease and indicated the necessity of an immediate campaign to save the cattle interests of the island. Today the English people are comparing statistics and they find that the British cow is yielding thirty per cent less milk than the cow of Denmark on the same quantity of food. Such instances serve to show the value of the scientific and statistical methods by which every country is extending its animal resources.

In our own country the total value of all farm animals in 1896 was reported at $1,997,000,000. Four years later, in 1900, $2,213,000,000. In 1891 our exports of farm products alone amounted to $950,000,000, and made up sixty-five per cent of our entire export trade. Of this amount, $250,000,000 worth consisted of animal products. To protect ourselves and our customers, the United States government, during this year, inspected a million and a half of cattle for Texas fever, and vaccinated thousands of cattle for black-leg. Out of a total of five million cattle inspected for various diseases, 12,500 were condemned. Out of 24,000,000 hogs inspected, 80,000 were condemned. These are but a few statistics showing the enormous extent of our animal industries and the degree to which we have developed our system of intelligent supervision.

Our government exhibits commendable enterprise, also, in the introduction and encouragement of new species of domestic animals. The establishment of the reindeer in Alaska, while its ultimate success is questionable, has proved of considerable value on several occasions. The government is introducing the Angora goat into regions where it promises to add materially to the resources of the farmer. The last report of the Secretary of Agriculture turns our attention to the development of the animal resources of our island possessions. In Hawaii, for example, it is reported that live hogs sell for ten to seventeen cents per pound, chickens for $15 per dozen and eggs for forty to fifty cents per dozen, all being in the category of luxuries. It is proposed to increase these products in the islands until they can be sold as cheaply as the common foods.

We will now consider that vast field of economic zoölogy including all those animals directly beneficial or injurious to the human race, which have not been domesticated to any extent. We shall see that in this field, also, the present age is making great conquests—and some sad mistakes as well. A mere enumeration of the animals in question would occupy more time than can be spared, and the characterization of their economic features must therefore be very brief and imperfect.

You have probably heard the ancient saying that Amsterdam is built on herring bones, and we could all of us name less conspicuous communities of our own acquaintance whose existence depends on fisheries and related industries. The British boast that every acre of water about their island is more productive of wealth than so much English soil. The German Ocean produces annually eight to twelve pounds of fish per acre, or a billion to a billion and a half of pounds in all, and the German government is laboring to increase this output several fold. The sturgeon fisheries of the Volga river employ a hundred thousand men. Two years ago the fisheries of the United States yielded a return of forty millions of dollars, and the oyster business alone was worth fourteen millions, and yet the country had to import fishery products to the value of six million dollars, most of which might as well have been produced in American waters. Every one knows something of the methods and results of the work of our national and state fish commissions, to whom is due most of the credit for the prosperous condition of our fisheries. Not only do they raise fish artificially but they learn how to combat successfully some of the diseases and enemies that prey on our food fishes. America has the distinction of leading the world in the rearing and protection of fish. To show what one state can do in one year it may not be amiss to refer to the report of the New York state fish commission for 1898. In this year the state fish-car made forty-six trips, distributing thirty-five car loads of young fish throughout the state, and fifty carloads of fish were allowed to remain in the hatcheries for the next year's planting. The state expects to restock Lake Ontario with whitefish, and for this purpose hatched twenty million fry in one year. Our fish and game commissions frequently render good service by suggesting appropriate legislation and correcting faulty laws.

And now, to change the subject again, we shall not find in the whole range of animals another class of such power for good and evil as the insects. The time was, not many years ago, when the professional entomologist was dubbed a "bug-hunter" and regarded with undisguised contempt by the "*practical*" farmer and man of affairs. But the despised bugs kept rolling up accounts against our people and collecting them regularly, annually destroying agricultural products valued at $100,000,000 to $300,000,000. Our people set the bug hunter to devising some sort of relief from the insect plague, and the science of economic entomology was brought from Europe to America. Like many other things introduced from the old world, it has developed beyond all previous bounds and now America leads the world, without a rival in the science of applied entomology. The present indictment against insects consists of five counts and is well enough expressed in the words that I shall quote from Dr. Howard, the United States Entomologist.

"Insects are injurious:

1. As destroyers of crops and other valuable plant life. 2. As destroyers of stored foods, dwellings, clothes, books, etc. 3. As injuring live stock and other useful animals. 4. As annoying man. 5. As carriers of disease."

Another quotation shows the possibilities of these pests when acting in the first named role:

"At the present time almost every cultivated crop has not only its thousands upon thousands of individual insect enemies, but it is affected by scores and even hundreds of species. A mere tabulation of the insect enemies of the apple already recognized in this country shows 281 species, of clover 82 species, and of so new a crop as the sugar beet 70 species. The insects of the vine, of the orange, of the wheat crop, and, in fact, of all of our prominent staples, show equally startling figures."

In another place Dr. Howard quotes statistics showing that half the cattle received at the Union Stock Yards of Chicago in 1889, were afflicted with the ox bot fly, or ox warble, resulting in an actual loss of over three million dollars in six months from that one insect alone. Instances of insect ravages might easily be multiplied *ad infinitum*. The only redeeming feature of this situation is the wonderful industry of our scientists, who in all parts of the world, have studied the problems of fighting and exterminating the foe. The public has been educated, also, in a few of the fundamental principles of economic entomology, especially in regard to the value of birds in combating insects. We are becoming more than ever impressed with the dangerous character of flies and mosquitoes. Experiments in the eradication of mosquitoes have been carried on in many parts of the country. We all know what has already been done along this line in some tropical regions. Reference will be made in another paragraph to the extraordinary battle waged in California against the scale insects. Indeed, we may say, in summing up this part of the subject, that no warfare was ever more scientifically waged than the present warfare of civilization against noxious insects, allowing, of course, that there is still ample room for improvement.

But there is another side, a brighter side, to the insect question. Dr. Howard says:

"Insects are beneficial: 1. As destroyers of injurious insects. 2. As destroyers of noxious plants. 3. As pollenizers of plants. 4. As scavengers. 5. As makers of soil. 6. As food (both for man and for poultry, song birds and food fishes) and as clothing, and as used in the arts."

It is needless to add that our Department of Agriculture, under the lead of such experts as the late Dr. Riley and Dr. Howard, whom I have just quoted, has spared no efforts to reap a profit from the insect world wherever possible. These men have raised the science of economic entomology to a position of international importance through their most gratifying success in destroying our injurious insects by importations of their enemies from foreign countries. Experiments in this line began as many as thirty years ago, but, as Howard says, these were all "dwarfed into insignificance by the astounding success of the importation of *Novius (Vedalia) cardinalis*, a ladybird beetle, from Australia into California in 1889." I will condense Howard's interesting account of this and similar importations.

The citrus crops of California were suffering from the ravages of the white or fluted scale, a very small insect, which successfully resisted all measures employed against it, until it seemed that nothing could rescue the orange groves from certain destruction. At this juncture an *attaché* of the United States Division of Entomology visited Australia and succeeded in sending live beetles to California. Here they made themselves at home, multiplying with astonishing fecundity and attacking the scale insects so voraciously that within a few years they had literally exterminated them, and saved to the citrus industries of California, millions of dollars. Later, the United States entomologist had the pleasure of introducing the same beetle from California into South Africa, Egypt and Portugal, in each of which localities it was successful in combating the white scale. Another ladybird beetle imported into California "has unquestionably ridden many olive groves of the destructive black scale, and is today present in many other orchards in such numbers that the scale practically makes no headway." Many other experiments of this sort are under way in this country, and the efficacy of insect importations has been successfully tested in Hawaii and other lands.

The last annual report of the United States Secretary of Agriculture announces the success of another importation, a most unique experiment, the scene of which lies in California. For several years the fruit growers had attempted to raise Smyrna figs in California, without success. About six years ago the Division of Entomology determined to introduce from the Mediterranean country a little insect, *Blastophaga grossorum*, which there performs the very essential function of pollenizing the fig. After four or five generations of this fertilizing insect had been reared at Fresno, it became evident that it would supply the only factor lacking for the successful growing of figs. And now the "Smyrna figs" of the Pacific Coast bid fair to take their rank along with the standard figs of commerce. The United States entomologist is prepared to furnish colonies of these precious insects to all intending fig growers.

In the few instances just described we behold the realization of one of the chief ideals of economic biology—the subjection of useful species to the will of man.

Many insects might be named which are of great value in agriculture and commerce. We think at once of the silk-worm, which, as Professor Shaler remarks, is of more importance to us than the elephant, because it supports an industry out of which ten millions of human beings get their living. The bee is busy all over the earth, furnishing annually ten thousand tons of honey besides a valuable output of wax. The cochineal bug of the tropics, from which we derive our supply of carmine, once outranked all other insects in the commercial value of its product. Now, however, the aniline colors have largely superseded carmine.

Lest this paper should become merely a catalogue, we will spare you the repetition of a score or more of useful insects, merely remarking that possibly this class of animals comprises among its millions of species more friends than foes.

The birds undoubtedly rank next to the insects in economic importance. Nearly all of them are useful to man. A recent writer says that if all our native birds were to be destroyed man would die of starvation inside of ten years; mainly because of the unchecked increase of the insects that destroy our food plants. However this may be, we know that civilization is coming to a realizing sense of its dependance on birds in the war against noxious animals and weeds. This rational attitude toward our birds is due largely to the careful investigations of bird habits in every country of the first rank, particularly in our own land. The study of the relation of birds to agriculture has been very thoroughly cultivated by the United States Department of Agriculture, involving, among other methods, the investigation of the contents of about 20,000 birds' stomachs, and the careful tabulation of the articles of diet. The report published in 1899 states that only six or eight of our native American birds are found to be injurious to man. The

English sparrow and a few hawks and owls are condemned to extermination by this verdict of the department, while, on the other hand, some species formerly considered noxious are found to be decidedly useful. Everybody knows something about the campaign against the use of birds for millinery, and the measure of support that it has received. Our government and the various states are slowly modifying their legislation and coming to a more rational way of dealing with this question. Hereafter questions involving the welfare of any of our birds are likely to be referred to experts and not left entirely to the whims of the selfish or the tender mercies of the careless.

Of the higher animals, the mammals, there are scores of species whose value is well known. We need merely to mention the fur-bearing beasts, and our game animals to recall many species to mind. Of these, one and all, we confess in truth that we have sinned against them, and are reaping the results of our folly in a threatened extermination of some of the most valuable. The law makers are proverbially slow in acting where the fate of wild animals is concerned, as is too well seen in the case of the fur seal, the buffalo, and many kinds of wild game. Public opinion, however, is becoming stronger and with the help and backing of such organizations as the League of American Sportsmen it is likely to create gradually better conditions for all the animals that are hunted. The passing of the fur animals of the north has given a market value to such inferior pelts as those of cats, squirrels, rabbits and rats. The breeding of the Arctic fox promises to become a very productive industry in Alaska. As for leather, there seems to be no sort of hide from which it is not prepared today, from the skin of the eel to that of the elephant.

The discussion of our topic would be incomplete without mention of some of the blunders that man has made in his efforts to make himself master of the situation. The greatest of these, is the oft repeated sin of extermination. Something like a score of species were exterminated by man's misdirected industry during the nineteenth century, and many other species were so hard pressed that their disappearance from earth seems a question of a few years.

Another mistake that man has repeated often with disastrous results is the disturbance of the balance of nature by the introduction of wild animals from one country to another. The case of the mongoose in Jamaica is a good illustration, and so well known that it needs but a word of explanation. This mammal was brought from India to rid Jamaica of its pest of rats. Being free from its natural enemies, against which it had always competed in India, it soon became more of a nuisance than the rats that it had supplanted—in fact it completely upset the balance of nature, until the government of the island offered a bounty on its head. In spite of this unsavory chapter of natural history, it has required the most vigilant and determined opposition on the part of the United States government to prevent the importation of the mongoose by certain well meaning people, to the southern states and to Hawaii. Australia has suffered the loss of millions of dollars by the introduction of rabbits from England, merely to furnish game for hunting. The English sparrow came to America, by invitation, in 1850. We all know the result. The gypsy moth was turned loose in Massachusetts in 1868 or '69, by an innocent experimenter who wished to test its silk making powers. In twenty years the state government began the task of exterminating the moth, and now, after expending several millions of dollars, it finds the moth slightly ahead in the race. It is not strange that some of our scientific experts are trying to secure legislation that shall make it a criminal offense to bring into the country any foreign animal without the consent of some regularly constituted authority.

The future of economic zoölogy is filled with marvellous possibilities, and bright with promise. Applied zoölogy has taken its place among the arts and sciences of this progressive age and it has its skilled experts, its laboratories, its problems, and its solution of some of the vexatious questions of the day. Every fish hatchery, every experimental station, every agricultural college, and in a growing degree, every biological laboratory in the world, is a center for the prosecution of research and experiment in this vast field. Every discovery in biology, however impractical and trivial it may at first appear, conduces to some new triumph of man over the plastic forces of the animate world. Let us now consider a few of the lines along which the future achievements of this science are likely to be worked out.

1. We shall put a stop to the ruthless slaughter of our wild

animals wherever a civilized government has its "sphere of influence." We are likely to go still further in this direction and to set aside parts of the national domain as permanent parks in which every form of life shall be absolutely safe from man's marauding hand. Our own government has made a good beginning in the Yellowstone National Park. It remains now to secure tracts of available wilderness east of the Mississippi, and on the Pacific Coast. These reservations may be made valuable as forestry preserves, thus serving for all time a double purpose. Some of our states have made beginnings in this work, but we need more extensive reservations under federal control. The movement recently sanctioned by Mr. Hornaday, of New York city—the setting apart of a magnificent national reserve in southern Alaska, should be consummated without delay. We shall then have a place of refuge for the most superb mammals of the continent—the buffalo, musk ox, various species of bear, the beaver, many of the choicest fur-bearing animals, etc. It is a wise provision of Providence that has placed the noblest fauna of North America in our own domain and in a part of it that offers few temptations to the farmer or the miner. We shall certainly be very remiss if we fail to set apart and patrol this last refuge of the animals that are now hunted to the death.

Other countries are moving in this matter; even in Africa the protection of wild animals is to be undertaken by the powers. A convention signed by all the leading governments of Europe about three years ago, makes rigid restrictions on the hunting of game in Africa, and among other agreements, binds the signatory powers to encourage the domestication of the zebra, elephant, ostrich, etc., to prevent the transmission of diseases from tame to wild animals, to destroy the eggs of crocodiles, poisonous snakes, pythons, and in many other ways to render service to the useful or harmless animals that are in greater danger of extermination.

2. The most inviting service that awaits the energies of the economic zoölogist is the seeking out of new species of animals that shall be made useful to man in some new way. The number of animals that we utilize at present is surprisingly small. The total of animal species classified and named by our scholars was estimated at over 71,000 in the year 1830; 50 years later, in 1881,

there were over 311,000; while in 1896 there were said to be 366,000 species of animals having scientific names and recorded in the books. It is popularly believed that Adam finished the business of naming the animals before he left his residence in Eden, but we see from the figures just quoted that our own contemporaries found and named in the last three-quarters of the nineteenth century nearly 300,000 that Adam in his hurry had overlooked. And lest any one should think that the task was completed by the dawn of the twentieth century, we are told that the sum total of animal species is probably no less than ten millions. Indeed, Dr. Riley, once U. S. entomologist, estimated the varieties of insects alone at ten millions, which would bring up the sum of all animal species to fifteen millions. There remain, therefore, between nine million and fourteen million species still nameless—enough to furnish occupation for a long time to those who like that sort of thing. The real question, the main question now, is, What is the place of this species in the economy of nature? Is it injurious to the interests of man? If not, can we turn it to account in any way? The number of animals utilized by man is small, ridiculously small, it would seem. Shaler says that we use only 100 animals and 1,000 plants out of millions of species. Only twelve insects, he tells us, are used directly by man, and only two of these, the bee and the silk worm, can be called domesticated. America, the scene of so many of the latest triumphs of economic zoölogy, has added only one animal "of definite use to man over a wide field," to the list of domestic animals; and that is the turkey, which, by the way, became domesticated in Europe and was brought back again to its old home. These are the statements made by Shaler. It is true that we are now domesticating the buffalo, but with rather doubtful success. Peter Kalm, who visited this country in 1750, speaks of seeing domestic buffalo here. The early settlers of this country had their schemes for domesticating the moose, but they never accomplished the work. Other continents, also, have their unimproved opportunities. In Africa the breeding of zebroids, crosses between horses and the native zebras, promises to revolutionize the horse question. The bare possibility of originating on African soil a hybrid that shall compete successfully with the imported American mule, sheds great hope on the life of a South African, whatever his politics may be. So, indeed, the discovery of a single useful species, or the finding of a new use for an already serviceable animal, may be the means of adding millions to the revenues of a nation. No country can consider the exploitation of its animal resources completed until it has thus pressed the last recruit into its services and developed it to its highest capacity.

3. This brings us to the last and highest ideal to be sought in our use and treatment of animals, namely, the development of a stronger sympathy between us and our dumb friends by educating not only them but ourselves as well. Professor Shaler, in his convincing way, shows us that the animals most companionable with man have developed human qualities of mind by long processes of artificial selection. This is illustrated in what we all recognize as a well-bred dog; and who of us does not recognize a well-bred dog as instinctively as a well-bred man? That the domestic animal should become assimilated, in mental traits, to its lord and master is as fortunate as it is natural, for it opens up to us immense possibilities. If in the future as much attention shall be given to the improvement of animals in this line as in the past we have bestowed on the development of certain physical "points" in every breed of dogs or horses or pigeons, we may expect to bring our animals into more helpful and affectionate relationships with us than ever before. Indeed, such a result is inevitable as surely as it is ever attempted by the scientific breeder. If you find your dog companionable in your romps through the country or in the quieter hours that you spend at the fireside, why shall not his descendants in future ages be still more worthy to associate on terms of intimacy with the very best families? Have we ever thought of the possible social status of some of our dumb friends, a few centuries hence?

They say that "slumming" has a most wholesome influence on the social missionary. By a sort of natural reciprocity he receives from his lowly environment as much as he gives, and so he develops a fine personality while sacrificing himself for others. It is equally true that if we adopt the honest and human attitude toward the animals, using them for our convenience, if we choose, but treating them always with the consideration due to every fellow creature, we shall minister to the development of our own characters. This high philosophy is not inconsistent with the proper use of animals in any kind of service, nor does it prevent the destroying of those forms that torment ourselves or our animal friends. In some countries, as, for example, India, many forms of animals are deified, housed in temples, worshiped, and regarded with such awe that no one dares to kill one of them even to put it out of extreme misery. Yet our own people are much more humane than these worshipers of animals, and without any of their befogging and heathenish philosophy. As we extend our power over the animals it will ever be with a growing sense of respect for their myriad forms, and a corresponding sense of our own responsibility to their Creator and ours for the way in which we exercise our undivided dominion.

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of the

Buffalo Society of Natural Sciences

A REVIEW OF THE WORK DONE BY THE BUFFALO SOCIETY OF NATURAL SCIENCES IN CO-OPERATION WITH THE PUBLIC SCHOOLS.

by

Carlos Emmons Cummings

A. B., M. D.

Secretary of the Buffalo Society of Natural Sciences

BUFFALO 1906

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OLUME VIII No. 4

Review *of the* Work Done *by the* Buffalo Society *of* Natural Sciences *in* Co-operation with the Public Schools

by

CARLOS EMMONS CUMMINGS, A. B., M. D.
Secretary *of the* Buffalo Society *of* Natural Sciences

From the day of its inception, one fundamental principle has ntrolled the policy of the Buffalo Society of Natural Sciences. ealizing the important place which a great museum must eventlly take in the educational system of its home town, we have ways endeavored to get into the closest and most effective relanship with the public schools of our city. Every facility which had to offer to the student has been freely and continuously aced at his command. For years the science teachers of the city ve been in the habit of bringing their classes to our building, d we have supplied them with room and materials for their rk. In the study of geology, thousands of high school pupils ve received great benefit from our collections of rocks and inerals, and our display of native birds and animals has been of e greatest help to the classes in zoology and natural history.

At the beginning, it was the custom for the teachers to acmpany the classes and take charge of their work while here, the useum offering simply its collections and rooms, no attempt ing made to provide lectures or instruction beyond what was splayed. In time, however it was found that certain topics were such universal interest that they would warrant special attenn, and so the plan of special lectures for the schools came into ing. A series of talks on "Bees", "Birds" and "Insects" was ranged for Saturday afternoons, and were open to such of the ades as cared to come, and met with much success. The attendance at these talks was entirely optional with the classes, the Department of Education simply recommending that as many schools as possible take advantage of them.

As a part of the work, it was expected that the classes which came to the talks would take the opportunity of visiting all the rooms of the museum, and in this way become acquainted with the fact that there were here displayed for their benefit many interesting and valuable specimens illustrating topics which would be an important part of their later studies along scientific lines. As a further inducement to the schools to come to our museum, the large lecture room was equipped with a suitable apparatus for the projection of slides, and this was announced as being available for any school or class that cared to come and bring slides to illustrate a talk by the principal or teacher. For some months this room was in nearly constant use by the schools, the teachers coming with the classes and making whatever explanation was necessary as the pictures were thrown on the screen by the operator. In one series given to the third and fourth grades, on geography, over 14000 children attended. Shortly, however, after this plan had been inaugurated, the Department of Education considered it advisable to equip nearly all the schools with lanterns, and therefore at this time only a few schools are under the necessity of coming to our rooms when they wish to display slides to their classes.

In the spring of 1905, through the efforts of Hon. T. Guilford Smith, the President of the Society, a plan was arranged with the Department of Education by which our Museum became an important factor in the work as required from the pupils of the grammar grades. A suitable collection to illustrate the weapons and utensils of the colonial days, used by Indians and whites, was arranged, and notice was sent to all classes studying American History that these things were on exhibit for the schools, and could be seen by applying at the Museum for a suitable hour to be assigned. It was expected that the teachers would bring their classes and explain the utensils and other interesting specimens to the classes from the cases. This plan did not meet with great enthusiasm. The teachers, already having as much special work as they could be reasonably expected to carry, preferred having some one else give the talks, and Dr. Carlos E. Cummings, the Secretary of the Society, was asked to take this matter in charge. This being done, the visits of the schools took the nature of regular

Carlos Emmons Cummings, A. B., M. D.

Secretary of the Buffalo Society of Natural Sciences

lectures, and met with great and immediate success. Although attendance was not required, so many teachers applied for dates that in this course, as can be seen in the appendix, thirty five separate lectures were given, to an attendance of nearly 5000 children. These talks were followed by a series on birds and bees to the seventh grade, thirty lectures in all, to an attendance of 6700.

During the summer arrangements were perfected to make this work an integral part of the public school requirements. The Department of Education decided to make the attendance upon these talks compulsory on those classes included in the grammar grades, and the Society secured the services of Dr. Cummings for the following year. He has since had charge of this work, giving all the talks and preparing all the material used in illustrating. Regular schedules were prepared by the Department of Education, and sent to all the principals, notifying them upon what day to send their classes, and the Society also sends to each principal a card announcing the lecture so that any alterations or changes in the schedule can be arranged for. At the end of each course supplementary lectures are given to accomodate those schools which for any reason have been unable to come at the scheduled date. As a convenience in keeping the records of each course, each teacher is expected to register at the time of the talk her name, the school she represents and the number of boys and girls she has with her.

A great part of the work of the Secretary is taken up in preparing the material used in illustrating the talks. Lantern slides are used freely. To facilitate the manufacture of these pictures, a dark room was fitted up, and materials secured, and we now have available a considerable number of slides, and more are being constantly added Within the year nearly six hundred slides have been made here in the museum, and the files include over a thousand negatives that can be made up on short notice if needed. (For a complete list of slides on hand, see Appendix D). A trip to Jamaica during the month of April yielded nearly 500 negatives, (vide Appendix B), and a visit to the copper country of Lake Superior furnished some valuable material (Appendix C).

Series I. was illustrated by a fine collection of relics and material borrowed, as well as that in the cases of the Museum. The boys were particularly attracted by the exhibit of guns and weapons, while the girls showed more enthusiasm over the spinning wheels and articles of housewifery. This series was repeated to the eighth grade, using the same material. No slides were shown in these courses.

In the bird talks, actual specimens of the birds described in Mr. Burroughs' splendid stories were shown, and then a series of pictures was thrown on the screen showing the homes of the birds and the enemies which are liable to attack them. These talks were possibly the most popular of any given. For illustrating the bee talks a hive of live bees was secured, the walls of the hive being made of glass so that the bees and comb can be plainly seen. Another empty hive was used, to show the frames, comb, queen cells, and general arrangement. A full set of bee-keeping utensils gave the children an idea of the methods used by the bee-keeper in handling his charges, and with the help of the slides, many features of the anatomy, as well as the customs and habits of the bee were explained. Two cases were arranged, one showing a fairly complete series of the mineral products of the United States in the crude state, and these were used in the lectures to the fifth grade children. Similar cases showed tropical products, notably cocoa, vanilla, cocoanuts, coffee and rubber, and were used in the sixth grade work. The fine slides illustrative of Jamaica products will be available in addition for the work next year. The Physiology talks were an effort to perform for the children the experiments required in the new physiology syllabus, with suitable explanation, and were so successful that at the request of the teachers, an evening was arranged for them alone, at which time they were at liberty to ask questions of the lecturer in regard to the work, and the methods of performing the experiments before their classes. Although the talks were given during the required school hours, and attendance was in a sense compulsory, it has been found that both teachers and children have taken the greatest interest in the work. One boy last year came three different times to the bird talks and several teachers requested the privilege of bringing their classes a second time. In a few of the courses the lectures were announced to the teachers at grade meeting, and they were asked to register their schools, if they cared to have their classes attend. In every case nearly every teacher registered immediately or shortly after the beginning of the series. The lectures are given at 10:30 and at 2:00, the schedule being arranged so that those schools situated the farthest from the museum have an afternoon assignment. This prevents any necessity for hurry in getting back to school for an afternoon session. The attendance at the talks has averaged about 125, the number being purposely made small so as to make them as informal as possible and to encourage the children to ask questions as well as answer them on the topics presented.

A report of this kind would be quite incomplete were not some acknowledgement made to the officers of the Society by whose persistent and effective efforts our present effective system has been developed. Among these are the late Dr. William C. Barrett, one time Director of the Museum of our Society; Mr. Frederick Houghton, who was responsible for the travelling exhibit scheme, which is now being taken up by the large museums of the country; Dr. Lee H. Smith, for many years the President of the Society, under whose administration the lectures were brought to a systematic basis; Dr. Elizabeth J. Letson, the efficient Director of the Museum, on whose shoulders the greater part of the routine in arranging the work has fallen; and Mr. Henry Richmond, Chairman of the Education Committee, who has been largely instrumental in getting recognition and assistance from the City in carrying on the work. It is with particular pleasure that the Society acknowledges here its great obligation to the Hon. T. Guilford Smith, Member of the Board of Regents of the University of the State of New York and President of the Buffalo Society of Natural Sciences since 1903. Although closely connected with nearly every public movement that concerns the best interests of our City, Mr. Smith has found time to place our Society on its present high level of efficiency. Believing firmly that in co-operation only can the best results be secured, he has succeeded in associating all the various and disconnected interests represented in the school work, making them one and uniform, working to a common end, and accomplishing an amount of good which is most remarkable considering the unfortunately limited facilities of the Society at the present time.

◆

COCOON OF ATTACUS CECROPIA

BREAD FRUIT TREE

Appendix A

Schedule of Lectures delivered to grammar grades, 1905-6.

No.	Subject	Grade	Date begun		Date ended	Number of Lectures	Attendance
I	**Colonial and Indian customs**	9	March 21	to	March 31	18	1950
II	"	8	April 5	to	April 24	17	3000
III	**Birds**	7	April 24	to	May 8	15	3360
IV	**Bees**	7	May 22	to	June 5	15	3350
	Summer vacation.						
V	**Birds**	7	Oct. 16	to	Nov. 2	26	2997
VI	**Mineral products, U. S.**	5	Nov. 13	to	Dec. 21	40	3732
VII	**Physiology**	9	Jan. 3	to	Jan. 5	5	162
VIII	**South American products**	6	Jan. 10	to	March 1	45	3909
VII	(continued)	9	March 1	to	April 1	16	1743
IX	Bees	7	May 14	to	June 1	23	2780
9		5				220	26983

Appendix B

To the President,
and Board of Managers of the
Buffalo Society of Natural Sciences:

I have the honor to submit to you the following report of my trip to Jamaica, W. I., undertaken in the interests of your Society.

Leaving Buffalo April 2, 1906, I proceeded direct to Philadelphia. Here I spent a day with Dr. W. P. Wilson, of the Philadelphia Museums, and was entertained by him in a most cordial fashion, being personally shown through the buildings, and obtaining from him a detailed description of the work being done in that city in connection with the school department. I also visited the Academy of Natural Sciences of Philadelphia, spending several delightful hours in examining their magnificent collections.

CACAO PODS JAMAICA

I sailed for Jamaica on the 'Admiral Samson' of the U. F. Co's Line on Thursday, April 6. Apart from the first day, which was quite rough, the weather during the five days on board was ideal. Port Antonio was reached on Monday morning, and immediately on landing I secured rooms at the Tichfield Hotel. The first day was spent in unpacking and looking about the town, which affords a multitude of interesting features to the tourist

The next morning was taken up by a drive to Blue Hole, where we had our first experience with freshly gathered cocoanuts. Being prepared to appreciate this highly exploited feature of the tropics, its lack of any particular individuality was rather disappointing. Here is located one of the innumerable stations of the United Fruit Company, and we watched with great interest the process of loading bananas on the small sail boats to be transported to Port Antonio. In the afternoon a drive was taken to St. Margaret's Bay, and on the following morning Windsor and Mooretown were visited. Here we saw and photographed many cacao plants, as well as the ever present banana and cocoa palm. The afternoon being quite rainy, advantage was taken of the opportunity to photograph a series of tropical fruits in the freshly gathered state. Thursday morning was given over to a trip by carriage to Annotto Bay, which place we reached about three in the afternoon. Owing to the intense heat, and the very interesting nature of the place wherein we found ourselves, it was decided to remain there until the next morning. The afternoon was spent in a study of the methods of gathering and loading bananas, this being one of the principal shipping stations of the U. F. Co. Leaving Annotto Bay Good Friday Morning, the drive continued over the magnificent Blue Mountains, through plantations of banana, cacao and cocoa palms, to Castleton Gardens. Here lunch was obtained, and at three in the afternoon the Constant Spring Hotel was reached. This Hotel being but a short ride from Kingston by trolley, it was made headquarters during the remainder of the trip, as the temperature in Kingston is rather trying during the day.

Saturday morning I visited Kingston Institute, and was disappointed in not seeing Mr. Cundall, the Secretary in charge, for whom I left a card with my address. After carefully examining the collections in the Museum, I returned to the Hotel, and in the afternoon a drive was taken to Hope Gardens, where I added several negatives to my series of pictures on the tropical fruits

CURING CACAO IN THE SUN, JAMAICA

SUGAR CANE, JAMAICA

and products. Particularly was I pleased to secure views of growing vanilla and sugar cane.

Easter Sunday was devoted to a drive to Spanish Town and Bog Walk. The day was cloudy, and apart from a considerable series of banana pictures, nothing of particular value was secured.

Monday was rainy, and we were quite satisfied to rest throughout the day, remaining quietly at the Hotel. The next morning a trip to the Mona Sugar Estate yielded a splendid series of photographs of cane, and other features connected with the production of sugar and rum. Returning to Kingston, we went to the wharf to see off some of the party, and then I went to the Institute and arranged to lecture there on the following Saturday evening.

The next morning, after a very early breakfast, we took the train to Mandeville. Alighting at Williamsfield, a three mile drive brought us to the Hotel, in a most picturesque location. Mandeville lies in the centre of the coffee and orange district. We had no more than finished our dinner when we were assailed by a most terrific hail storm. It was a most amusing sight to see the natives scrambling around gathering the little lumps of ice, and I was assured by the propietor of the hotel that they had never seen any ice before that was not manufactured. At any rate, they watched the little masses melt in their fingers with the most intense interest. The rain continued until dark, when the stars came out in great brilliancy.

Thursday morning, after a five mile drive through a country which seemed to produce oranges by the ton, we reached the Brokenhurst Coffee estate, where we were met by the overseer and conducted through the mills. I secured a fine series of coffee pictures, but the season being past was unable to get as fine a collection of pictures of the berry as I would have liked. Immediately on reaching the Hotel, the rain began, and continued till dark, as on the first day.

Bel re-tiro, an estate given over largely to the production of pimento, was visited the next morning. The estate is up on the mountains, and the view from the verandah of the house is unsurpassed on the Island. Owing to the almost continual rain, all the plates that I had with me at this place became damp, and my pictures taken here were not satisfactory The afternoon rain came on promptly according to schedule, and lasted till dark, as usual.

The next morning we arose at 4.30, and after a most delightful drive over the mist covered mountains, arrived at Williams-

MOORETOWN, JAMAICA

NATIVE HUTS NEAR WINDSOR, JAMAICA

field in time for the early train. Kingston was reached without incident, and in the afternoon I visited the institute and made final arrangements for my lecture in the evening. Owing to a rather exaggerated participation in oranges at Mandeville I was feeling rather 'seedy', as the hotel clerk expressed it, but was able to hold up till my lecture was over, and then promptly collapsed on reaching the hotel. I remained in bed the following day, Sunday, and on Monday devoted what little energy I had left to packing up my property.

The boat left Kingston at 1 P. M. on the following day. After stopping at Morant Bay, where to my regret I found it too late in the day to secure good pictures of the bananas being taken aboard, we cleared for Boston at one o'clock in the morning, all hands aboard. Two days on the water completely dissipated my indisposition, and Boston was safely reached at twelve o'clock on the following Sunday night.

We landed at seven o'clock on Monday morning, and after spending two days in visiting the innumerable points of interest about the city returned to Buffalo.

On unpacking my trunks at the hotel I found that owing to somebody's carelessness my trunk had been standing in several inches of water for some days, and as a result a quantity of specimens of tropical fruits, etc., that I was bringing to the Museum were mouldy. However I succeeded in getting safely here specimens of cocoa, cane, cocoanut, tobacco, ginger and others of interest.

My pictures, however, with one or two exceptions, were good. I secured in all something over four hundred negatives, most of which have been made up into slides and added to our collection.

Among the slides may be mentioned the following:

A series of twenty on banana culture and shipping.

A series of thirty two on native fruits, showing plant, form and structure of the fruit.

A series on sugar, showing canes, wagons used in hauling, crushing mill, boiling house, etc.

CANE FIELD, JAMAICA

A series on coffee, showing the plant, blossom, berry and apparatus used in curing.

A series on cacao, showing tree, pod, sectioned pods, native methods of preparation, etc.

A series on the cocoa palm, showing tree, nuts and leaves.

A series on tropical scenery and vegetation.

A series showing native customs and habits.

Very respectfully submitted,

Carlos E. Cummings, M. D.,

Secretary.

Appendix C

To the President,
and Board of Managers of the
Buffalo Society of Natural Sciences.

GENTLEMEN:

I respectfully submit to you the following report of the trip taken by me to the copper country of Lake Superior. I left Buffalo on the steamship Juniata, Sunday, June 17th, 1906. The trip up the lakes was not particularly pleasant owing to the fact that the first four days were marred by nearly continuous rain. I was therefore, unable to procure very many photographs of the boats and ore docks which I especially desired to use in illustrating the shipping and handling of the ore. I left the boat at Houghton, Michigan. I had the pleasure of meeting Dr. Koenig of Philadelphia who occupies a position as Professor of Chemistry in the Michigan School of Mines at that place. I spent a very pleasant evening with him discussing the geology and conditions of the mines and obtained much valuable information.

The following day I visited Isle Royal mine in the morning and by presenting the letter of introduction which you very kindly furnished me before starting, I secured the attention and courtesy of the foreman of the shaft who very kindly allowed me to select such specimens as I desired and who gave me several interesting pieces which he had gathered for his own use. I brought back from this shaft some pieces of the Amygbaloid and Epidote and a very fine mass of Metallic copper with other specimens illustrating the nature of the ore produced at this time. Owing to the continual rain of this day I was unable to procure photographs of the shaft or machinery. In the afternoon, the weather having cleared, I visited the stamp mine of the same company and met with every courtesy, being shown through the different buildings and having the process thoroughly explained to me. I secured here specimens of the concentrates and some very fine samples showing metallic copper and metallic silver in the same piece. I secured photographs at this time illustrating the appearance of the buildings, the cars in which the ore is carried, and the disposal of the sand from which the copper has been extracted.

SHAFT HOUSE, RED JACKET MINE, CALUMET PROPERTIES

[illegible], MICH

The following day I had the pleasure of accompanying Dr. Koenig to the Calumet properties where we visited the shafts and buildings of the Red Jacket and Tamarack No. 4. We procured here specimens of the cement copper and conglomerate or pudding stone deposits which illustrate quite satisfactorily the form of the metal produced here. A very pretty specimen of Azurite and Malachite was secured at the Red Jacket mine. A careful study was made of the machinery used in raising and crushing the ore and the methods employed in its preparation. Owing to the rain a visit arranged to the smelting works on the following morning had to be abandoned.

On the return trip, the weather being more favorable, pictures were secured of the locks at the Sault and of the ore boats.

This region offers many very interesting features and it is to be regretted that the limited time at my disposal prevented me from making a more complete and satisfactory study.

Very respectfully submitted,

Carlos E. Cummings, M. D.,
Secretary.

Appendix D

Series of slides used in the Lectures.

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Notes on Jamaican Hemiptera

A Report on a Collection of Hemiptera made on the Island of Jamaica in the Spring of 1906

BY

E. P. VAN DUZEE

BUFFALO, NEW YORK
1907

EDWARD P. VAN DUZEE.

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VOLUME VIII No. 5

Notes on Jamaican Hemiptera:

A REPORT ON A COLLECTION OF HEMIPTERA MADE ON THE ISLAND OF JAMAICA IN THE SPRING OF 1906

By E. P. Van Duzee
Buffalo, N. Y.

In the spring of 1906 it was my privilege to spend a few weeks collecting Hemiptera on the Island of Jamaica. I sailed from New York March 17th, arriving at Kingston on the morning of March 23d; returning I left Jamaica on April 19th. This gave me nearly four weeks on the island, but annoying rains on several days and three days of illness reduced somewhat my time available for field work. I was there at the close of the dry season when insect collecting was probably the poorest. The conditions there I found somewhat unfavorable when compared with those I was used to in the various portions of the United States where I have collected. The cost of living was high and the accomodations and food, except at Kingston, Mandeville and Port Antonio, were very poor. The heat also was a hinderance to my work, especially at Kingston, Balaclava and Montego Bay. At these warmer stations I generally had to be in out of the sun by nine o'clock, which was soon after the dew was off the vegetation, and could rarely start out again before three or four in the afternoon. In the short tropical days that left but little time for actual work in the field. At the higher altitude of Mandeville and on the northern side of the island the heat was less troublesome but there the rains would frequently begin by ten or eleven in the morning and practically put a stop to work for the day. Under these conditions I think the results of my work as given in the following pages is on the whole satisfactory. The very large proportion of new species, more than one third of all those taken, shows how much need there is of thorough systematic collecting on this island, and the same is probably true of many of the other West Indian islands.

The localities and dates where most of my work was done are as follows:

Rock Fort, just east of Kingston. Here I collected along the shore road from the terminus of the trolley line for about three miles toward Morant Bay. The collecting was excellent after passing the old fort.

Kingston, March 26th. I left the trolley at a cross road about a mile south of the Constant Spring Hotel and worked toward the hills along the roadside and on adjacent fields. Collecting poor.

Kingston, March 27th. At Hope Gardens. Here I found good collecting along the lane leading from Papine to the Garden office and back of the office buildings.

Mandeville, March 29th to April 4th. I stopped at the Newleigh House and worked in the fields and on the hillsides in the neighborhood, where the collecting was the best I found on the island.

Balaclava, April 4th to 6th. Stopped at Malvern Hill and worked in the near-by fields and roadsides and along the railroad track for about a mile east of the town.

Montego Bay, April 7th and 8th. Here I worked along the shore toward the "Doctor's Cave", up a dry ravine behind the village, and along the road running up the hill to Paradise Pen. It was too dry and hot for good results here.

Appleton, April 9th. Collected east along the railway and on a cross road to the Shiloa River with good results.

Port Antonio, April 12th. Here the land was under complete cultivation and there were no good opportunities for collecting within walking distance of the Hotel.

St. Margaret's Bay, April 12th. Collected along the Rio Grande River just east of the village in the afternoon with satisfactory results.

Hope Bay, April 13th. Worked near the river and along the road east of the village. Collecting poor.

Richmond, April 14th and 15th. Worked on the Alexander estate and along the road north of the town and for about a mile south of the railway station at Troja, the next station south of Richmond. The collecting was good at Richmond but poor at Troja.

Kingston, April 17th. In company with Mr. P. W. Jarvis I worked along the railroad track for about a mile west of the station and south to the shore with good results.

An examination of the species here listed will show a close parallelism with those recorded from the islands of Grenada and St. Vincent by Dr. Uhler. While each of these islands has its peculiar forms there are many species that seem to be common to all the larger islands and the coasts adjacent to the Caribbean Sea. Most of these widely distributed species spread northward only to Florida or at most along the Gulf coast to Texas and Mexico. A few however are found as far north as Canada. The material taken by me was too fragmentary a representation of the Hemipterous fauna of Jamaica to allow of any discussion of the geographical distribution of the genera and species or of a comparison of this fauna with that of the neighbouring islands or of the adjacent mainland.

I wish to express here my indebtedness to Dr. O. M. Reuter for his kindness in working up the difficult but interesting Capsids taken by me, and to Prof. E. D. Ball for his very valuable assistance in the verification and determination of the Homoptera.

In the following pages I have recorded *234* species as having been taken by me on this trip. Of these *85* species or varieties are new to science and among the latter are representatives of 9 new genera. An index to these new genera and species will be added at the end of the list.

Family Thyreocoridæ

Thyreocoris minutus Uhler.

Abundant at Mandeville on the hillsides back of the Newleigh House where I swept it from low weeds. I also took it at St. Margaret's Bay and in other parts of the island. Dr. Uhler described it from Cuban material and Prof. E. D. Ball has sent me specimens taken in Hayti. Aside from its small size it may be distinguished by its dull black color, closely punctured surface, transversely rugose pronotum and scutellum, prominent humeri and yellow elytra. The largest specimens I have seen are rather smaller than the smallest *tibialis* and *pulicaria*. I have followed Dr. Oshanin in using this generic name in place of *Corimelæna*.

Thyreocoris cognatus n. sp.

Very near *pulicaria* from which it may best be distinguished by a comparative description. A little smaller and somewhat more elongated, punctures coarser and deeper over the whole surface. Head distinctly longer and more narrowed anteriorly. On the pronotun the callousities are more conspicuous as smooth slightly elevated surfaces and there is a slight trace of a longitudinal median line; the carinate lateral edge is continued around beneath the feebly elevated humeri, not conspicuously interrupted beneath the prominent gibbous humeri as in *pulicaria*. The antennæ are more slender and with the tibiæ and tarsi are paler; the pale margin of the corium is more distinctly punctate; the posterior margin of the scutellum is pale in all the specimens before me, and the margin of the connexivum posteriorly is marked with about three pale points in place of the pale line [sometimes broken] found in *pulicaria*. The genital segment of the male is a little longer and narrower with the sides more oblique than in *pulicaria*.

Described from numerous specimens taken at Rock Fort near Kingston. From *tibialis* this species differs in being proportionately longer and narrower, with a longer head and more closely punctured surface. The corium is pale with no indication of a black costal streak.

Thyreocoris basalis Germar.

Of this well marked species I took several examples at Balaclava, and found them not uncommon on weeds along the roadside at Richmond.

Family Scutelleridæ

Diolcus irroratus Fabr.

I took large numbers of this insect at Rock Fort on a coarse almost shrubby weed that has much the appearance of a Chenopodium, in the spiny angular bracts of which these insects were well concealed. I also took it near the Constant Spring Hotel, and at Mandeville and Montego Bay. In this species as in our northern *Eurygaster alternatus* the males were very uniformly punctured or obscurely mottled while the females were strongly marked. Prof. Ball has sent me a fine series of this insect taken on Hayti where it seems to be as abundant as in Jamaica.

Homœmus proteus Stal.

I took single examples of this species near the Constant Spring Hotel, at Balaclava, Montego Bay and Richmond.

Family Pentatomidæ

Mormidea pictiventris Stal.

Not uncommon at many places on the island. I took them at Mandeville, and in abundance at Balaclava. Most of these were deeply colored. Specimens in my collection from Columbia and Mexico are much paler.

Mormidea sordidula Stal.

I swept two examples of this from weeds along a roadside just north of Richmond on April 15th. In my collection is an example taken at Linares, Mexico by Prof. Gillette in July 1899. A similarly colored species from Trinidad, W. I., I have determined as *scutellata* Westw. It may be distinguished from the present by the pale venter and narrow pale calloused margins of the scutellum.

Oebalus pugnax Fabr.

One example swept from herbage by the roadside at Richmond.

Euschistus crenator Fabr.

Not uncommon in many places. I took it at Rock Fort near Kingston, Balaclava and Montego Bay. In each locality they were taken singly from bushes and coarse weeds.

In this species as I distinguish it the subacute humeri are directed slightly backward. In all my Jamaican and Mexican specimens the humeri are decidedly broader with their anterior margins convexly rounded. Those from the Island of Trinidad and Hayti have the humeri more acute and less recurved.

Euschistus bifibulus P. B.

This was a much more abundant species than the preceding all over the island but it was more common in the more humid and cooler localities while *crenator* affected the hotter and dryer parts of the island. In this species the humeri are produced in black acute horns which are directed distinctly forward. There is an obvious paler vitta connecting the humeri which is dislocated about an angular blackish mark on the median line, and the genital segment of the male is short with its apical margin broadly and deeply excavated. In *crenator* this segment is longer, narrowed posteriorly, with the apex feebly notched. I have received one specimen, apparently of this species, from Mr. Underwood that was taken in Costa Rica. It differs from the Jamaican specimens in having the humeri more obtuse but still directed slightly forward, and the latero-anterior margins are more strongly denticulated.

Euschistus ursus n. sp.

Allied to *rugifer* Stal and pertaining to that section of the genus as arranged in the *Enumeratio*. Size and form of *bifibulus* nearly. Greyish testaceous; above coarsely punctured with black or dark brown, these punctures gathered into blackish areas on the pronotum and leaving a smooth bisinuated pale vitta between the humeri, produced at the middle in an abbreviated longitudinal vitta; base of the scutellum with three indefinite smooth pale spots. Elytra dotted with black, each dot covering from three to eight punctures. Antennæ and legs pale, the latter faintly dotted with brown. Beneath paler, obscurely maculated with a darker shade; median line and tip of the rostrum, a dot above the insertion of each leg, another on the anterior angle of the propleura behind the eye, and a spot at each incisure on the margin of the venter, black.

Head rather long, rounded before; cheeks and tylus of equal length, the latter quite regularly punctured with black Antennæ unicolorous impunctate; first joint scarcely attaining the [illegible] of the head, second distinctly shorter than the third. Humeral angles of the pronotum prominent, rounded before, subangular behind; latero-anterior margins quite strongly arcuated, blackened by the seggregated punctures, strongly crenulated with pale. Membrane obscured, impunctate, nervures irregularly bent but scarcely anastomosing. Connexivum closely punctured, the edge blackish with a round pale spot at the middle of each segment and an obscure line on the incisure. Rostrum attaining the posterior margin of the metasternum. Genital segment of the male rounded behind, feebly concave at apex. Length 10 mm.

Described from one pair taken at Rock Fort near Kingston and two males from Port au Prince, Hayti, received from Prof. Ball. This species has the size and form, nearly, of specimens of *biformis* Stal with rounded humeri, but in most of its characters it is much nearer to *rugifer* Stal. In the Haytian examples the dotting of the elytra is almost obsolete and the pale calloused vitta of the pronotum is sometimes inconspicuous. I have no doubt but this insect is the same as that figured by Palisot de Beauvois as the female of his *Pentatoma obscura* on plate 10, figure 9 and described on page 149 of his work. His male *obscura* however is the same as *crenator* Fabr. and I do not see how we can restrict the name *obscura* to the female of his species: I have therefore thought it best to rename the species.

Thyanta perditor Fabr.

Abundant everywhere on the island especially in the dryer localities about Kingston and at Mandeville and Balaclava. In my collection are specimens from Hayti, Mexico, Columbia and Peru. This species seems to be more constant in coloration than *custator*. All the examples before me have the pronotal band distinct, anterior to which are two round black points, and the edge of the abdomen is fulvous with a black point at each incisure. The base of the head between the ocelli and a median line on the tylus are rufous; there are generally a few brown points near the base of the membrane. The pronotal angles in all my specimens are acute and distinctly inclined forward.

Thyanta antiguensis Westw.

I swept five examples of this species from a low whitish succulent weed, apparently allied to *Chenopodium*, growing in masses along the roadside to Rock Fort. These agree in every particular with the material from Hayti described in my List of the Pentatomidæ of North America.

Loxa flavicollis Drury.

I took numbers of this large Pentatomid on the dry hot hillsides above the Rock Fort quaries. Most of these were beaten from Acacia bushes, March 25th. On April 17th I found the larvæ with the adults near Hope Gardens.

Loxa pallida n. sp.

Closely allied to *flavicollis* but smaller and narrower with the ground color a paler yellowish green, that may in part be due to immaturity. Transverse rugæ on the vertex and cheeks much less distinct, these surfaces much more strongly punctured with rufous; calloused outer margins of the cheeks before the eyes rectilinear or very feebly concavely arcuated, not distinctly bowed outward as in *flavicollis*, with their apex a little more slender and acute before the tylus. Surface of the pronotum, scutellum and elytra very uniformly and closely covered with rufous punctures arranged in anastomosing transverse lines, between which are a few pale calloused points. In *flavicollis* the punctured lines are farther apart with the intervening surface minutely shagreened and irregularly blotched with pale, as is also the apex of the scutellum and the disk of the corium. Humeral spines proportionately a little more slender than in *flavicollis*, and the abdomen narrower; the connexivum scarcely projecting beyond the elytra, pale, punctured with rufous inwardly as in that species. Lower surface a little more closely punctured with rufous; the apical spines on the outer genital plates of the female more abrupt and slender. Antennæ and legs pale with no indications of dark punctures or markings except that the extreme tips of the tarsal claws are black. The second antennal joint is equal to the third, not distinctly longer as is generally the case in *flavicollis*. The rufous punctures form a tolerably distinct submarginal vitta about the head, pronotum and elytra as in the allied species. Length 19 mm.

Described from one female example taken with *flavicollis* at Rock Fort near Kingston. It is sufficiently distinct from that species as the above comparative description will indicate but it certainly is very close to *haematica* H. S. and may prove to be a pale form of that species. The difference in the color markings and habitat however seem to me to warrant its description as a distinct species.

Nezara viridula Linn.

I took a single example of this insect by the roadside near Hope Gardens at Kingston on April 17th. Later in the season it probably is not uncommon on this island as it is abundant on Hayti.

Nezara marginata P. B.

Abundant everywhere on bushes especially on the dry hot fields about Kingston. They fairly swarmed on weeds and low bushes along the river bank a little south of Hope Bay. In my collection are specimens from Peru, Bolivia, Venezuela, Costa Rica, Mexico, Hayti and the southern United States.

Piezodorus guildingi Westw.

I swept numbers of this insect from rank weeds along the roadside at Troja and Richmond, and also took them at Hope Gardens and near the Constant Spring Hotel at Kingston. All of my specimens have the base of the pronotum blackish bordered before by a pale calloused band. In none is the rufous band more than indicated. This band is beautifully developed in some examples kindly given me by Prof. E. B. Wilson which he took at Savannah, Ga.

Edessa meditabunda Fabr.

Swept from rank marsh plants growing along the railway tracks at Appleton. The larvæ were taken with the adults. This species seems to be widely distributed in tropical America. I have specimens from British Guiana, from the La Plata Country, and from Rio Grand de Sul and Victoria, Brazil. Distant places *rugulosa* Uhler as a synonym of this species in which I believe he is correct, judging from a typical female from the island of St. Vincent kindly sent me by Dr. Uhler.

Edessa chelonia n. sp.

Allied to *meditabunda* but larger and more ovate and depressed in form. Deep grass green; clavus and inner field of the corium chestnut brown varied with pale punctures. Three lines of these punctures follow the claval suture, from the outermost of which a few transverse abbreviated lines of punctures radiate into the brown discal area; against the outer border of this brown area lies an indefinite cloud of the pale punctures. Membrane fuscous. Outer edge of the head and pronotum slenderly bordered with pale yellow. Tergum dark blue-green. Antennæ pale becoming a little dusky toward the apex; the basal two joints dotted with brown. Legs pale dotted with brown; the dots nearly obsolete on the posterior pair. Lower surface pale green; the minute hind angles of the abdominal segments and an annulus about the pale stigmata blackish-green. Rostrum pallid with the extreme tip black.

Head, pronotum, scutellum and outer field of the elytra closely and finely punctured between fine irregular rugæ; inner portion of the elytra more irregularly punctured. Apex of the scutellum a little wider and more obtuse than in *meditabunda*. Lower surface more coarsely and rugosely punctured, nearly smooth along the middle line; ventral spine broad and flat, obtusely angled at apex. Metasternal plate broad, lateral angles small and abrupt, posterior margin broadly excavated for the reception of the ventral spine. Disk of the genital segment of the male piceous black, its apical margin sinuated either side of the broad shallow median sinus, outer angles obtusely prominent. Length to tip of the membrane 14 mm.

Described from ten examples, representing both sexes, taken with numerous young from small trees growing in the fields along the railway a little west of the station at Kingston, April 17th. In Stal's synopsis in the Enumeratio this species would fall in the section with *meditabunda*, but the depressed and much broader and more ovate form and the finer and closer punctures will at once distinguish it; the brown on the elytra is also confined to the inner field and the venter wants the black incisures and stigmatal lines. I have been unable to identify this with any of the described species in this large genus known to me.

Family Coreidæ

Chariesterus gracilicornis Stal.

I captured one pair of this species while beating weeds along the railway track at Troja, April 14th, and three examples at Hope Gardens near Kingston. The latter have the plates on the third antennal joint a little wider than do those from Troja but I cannot see that they differ otherwise. In one of the Trojan examples the third joint of the left antenna is wanting, the second joint is much longer and thicker than on the right side while the first and fourth joints are normal. Most of my specimens show a blackish vitta on either side before the ocelli, and in two females there are two broad black approximate longitudinal vittæ on the base of the pronotum. In all my specimens the incisures of the connexivum are faintly blackish.

Catorhintha guttula Fabr.

Not uncommon on low weeds at Rock Fort and Hope Gardens near Kingston the last of March and along the railway tracks west of the Kingston station on April 17th. Most of these specimens have the connexivum immaculate as in *selector* but in a few it is more or less maculated as is the case in specimens from Texas and Mexico in my collection.

Zicca tæniola Dallas.

Common. I have records of Mandeville, Balaclava, and Kingston where I found them in numbers on rank weeds about a brush pile at Hope Gardens. These average a little darker in color than a series I have from the island of Trinidad.

Chondrocera laticornis Lep.

This and the two following species were not taken by me but were kindly given me by my friend the late Albert Reinecke of Buffalo, an enthusiastic sportsman and student of birds, who visited Jamaica in 1903 and brought these back to me among other interesting insects and some land shells he gathered while on the island.

Sephina maculata Dallas.

Brought home from Jamaica by Mr. Albert Reinecke.

Anasa scorbutica Fabr.

Also taken by Mr. Reinecke in Jamaica with the preceding species.

Leptocorisa filiformis Fabr.

One example was taken at Hope Gardens near Kingston and another at Appleton on April 9th.

Magalotomus pallescens Stal.

Taken at Troja and Richmond. The males are pale and answer well to Stal's description except that the posterior femora are infuscated, with a pale spot before their apex; the females are nearly black with the pale pectoral vitta almost obsolete; the venter is black with a few pale points on the sides, legs blackish with the tibiæ and base of the femora pale; the basal joint of the tarsi is ringed with pale and there is a pale spot on the front of the posterior femora near the apex. A good series in my collection from the island of Trinidad exhibit variations in both sexes from the darkest individuals to the pale form described by Stal.

Harmostes serratus Fabr.

This species was not uncommon on the island. I took it at Mandeville, St. Margaret's Bay, Troja, and Richmond. These specimens are larger and darker in coler than some sent me from the island of Trinidad by Mr. Chipman.

In my collection I find a single example from Brownsville, Texas, that differs from *serratus* in being smaller, paler in color, and in having the second joint of the antennæ equal to the third and the rostrum barely attaining the intermediate coxæ. These characters are just those given by Dallas to distinguish his *affinis* from *serratus* and I think it quite likely that it may be the form described by him.

Corizus pictipes Stal.

A very abundant insect everywhere I collected on the island. Mr. Chipman sent me large numbers from Trinidad showing it to be equally common there. I have also received it from Mexico and Florida.

Corizus hyalinus Fabr.

I took this with the larvæ at Hope Bay. It may be abundant later. It belongs to subgenus *Liorhyssus* Stal.

Jadera sanguinolenta Fabr.

One example taken in a house at Mandeville. I saw broken remnants in spider webs about houses in several places, so, apparently, the season for its occurrence had about passed. Mr. Reinecke took it in Jamaica in February and I have specimens taken in British Guiana by Mr. Crew.

Family Metacanthidæ

Jalysus reversus n. sp.

Close allied to *macer* Stal. Pale ochraceous. Head with the basal collum and three longitudinal lines pale; the lateral interrupted by the antenniferous tubercles; the intermediate a little expanded between the antennæ and on the tylus; tip of the labrum black, polished; pale basal collum interrupted by the large red ocelli below which is a pale spot followed by a fuscous one behind the eyes; lower surface paler with an abbreviated rufescent vitta either side of the middle. Basal joint of the antennæ nearly or quite as long as the two succeeding together, strongly annulated with black, second a little shorter than the third, both of these joints dusky; fourth about two thirds the length of the second, black with the apical one third white and the extreme tip blackish; all the incisures pale. Pronotun closely and regularly granulated; anterior lobe clearly defined, sublunately convex posteriorly, anterior angles rounded, prominent; these and a median basal spot obscurely pale and calloused; posterior lobe gibbous, with a feeble pale median carina which becomes obsolete behind the middle, the posterior margin narrowly reflexed and pale, a little emarginate at the middle; anterior angles tuberculate, pale and calloused. Sternum darker rufous, mesosternum with two pale feeble median carinæ, divergent posteriorly; osteolar spine long, straight, rather stout and pale at base with a more slender black tip. Scutellum rather narrow, armed on the base with a long curved pale spine. Hemelytra almost attaining the apex of the abomen, greenish hyaline, costal nervure slenderly blackish, the other nervures and the clavus ochraceous, the latter transversely wrinkled. slender apex of the corium linear, defined within by a blackish nervure, reaching three fourths the length of the membrane. Membrane transversely wrinkled with about four simple straight nervures. Abdomen greenish above, at least on the connexivum, more ochraceous beneath and on the base of the tergum. Legs long and slender dotted and annulated with black, apex of the tibiæ and tarsi blackish. Length 6½ mm.

Described from 14 specimens taken as follows: Rock Fort, near Kingston; Balaclava; Montego Bay; Kingston, from the railway yards just west of the city, April 14th. It was a common insect everywhere on the island.

This form is closely allied to *macer* and *tenellus* Stal but the fourth antennal joint is white on the apical one third with the tip black, not black with the extreme tip white; the elytral nervures are ochraceous not testaceous white, and there are other points in which it fails to answer to Stal's descriptions. The apex of the first joint of the antennæ and the femora are clavate, brownish, tipped with pale. The greenish color of the abdomen and elytra may be dependant upon an immature condition, as some individuals are entirely ochraceous tinged with rufous in places, especially on the tergum.

Metacanthus decorus Uhler.

Taken at Mandeville and Balaclava. Apparently more characteristic of the higher elevations. In his Rhynchotal Notes, no. 10, Dr. Distant places this species as strictly conspecific with *Metacanthus capitatus* of Uhler and there certainly is nothing in the descriptions to distinguish the two species. Dr. Uhler's new genus *Protacanthus*, established for *decorus*, seems to differ from *Metacanthus elegans* only in having the rostrum a little longer and the spines at the anterior angles of the pronotum longer and more slender.

Family Lygaeidæ

Oncopeltus pictus n. sp.

Closely allied to *varicolor*. Orange fulvous marked with black and white. Head fulvous, apex of the tylus base of the vertex, occipital area, and antenniferous tubercles black; Antennæ black, proportionately shorter and thicker than in *varicolor*, second joint perhaps a little longer relatively. Rostrum black, shorter than in its ally, scarcely attaining the apex of the first ventral segment. Pronotum narrower than in *varicolor* with the lateral margins rectilinear, not arcuated; humeral angles not rounded; depressed basal margins narrow and broadly rounded, not broad and subangularly produced as in *varicolor;* color fulvous, base, sides, and median line black. Scutellum black. Elytra black with a large white spot on the base and another at apex, omitting the costal nervure, the apical spot obliquely produced and arcuated anteriorly; not cut square across as in *varicolor*. Beneath fulvous; meso- and meta-sternum, except their posterior margins, a cloud exterior to the coxæ, much smaller on the propleura, edge and apex of the venter and a discal area, which scarcely attains the base and extends to the margins on the fifth and sixth segments, black. Tergum apparently coccineous with the apex, narrow lateral margins, and a transverse vitta on the posterior segment, black. Legs black. Length: male, 10; female 12 mm.

Described from a single pair taken on the northern side of the island; the male at St. Margaret's Bay; the female at Hope Bay.

This species may vary in color as does its ally but the different form of the pronotum, as well as the shorter antennæ and rostrum will distinguish the species. It is also smaller and has the elytra proportionately narrower at base. My specimens of *varicolor* are from the island of Trinidad and agree very closely with Distant's figure in the Biologia.

Oncopeltus gutta H. S.

One male swept from weeds by the railway tracks near the Kingston station, April 17th. This corresponds with Distant's Biologia figure except that the ground color is a light scarlet including the entire head except the apex of the tylus and a cloud behind the ocelli, and the sides of the scutellum.

Oncopeltus sandarachatus Say.

Abundant everywhere I collected on the island. Those from the hilly districts about Mandeville, Balaclava, and Appleton were of the pale form as described by Say and were smaller. Those from the north side about Hope Bay and St. Margaret's Bay were more deeply colored and were larger. I can however find no specific characters to distinguish these two forms and all gradations occur connecting the two.

Lygaeus (Graptolomus) formosus Blanch.

I captured four examples of this pretty species at Rock Fort, and have in my collection another labelled Port au Prince, Hayti, that was received from Prof. E. D. Ball. Heretofore this species has been recorded only from the continental countries from Mexico to Venezuela.

Lygaeus (Ochrostomus) pulchellus Fabr.

Taken at Constant Spring near Kingston, in an old banana field overgrown with weeds; Montego Bay, April 8th, with the young; Richmond, April 15th with larvæ. Prof. E. D. Ball has sent me specimens from Port au Prince, Hayti.

Ortholomus jamaicensis Dallas.

I took occasional examples of this species at various places on the island and found it fairly abundant at Richmond. These specimens agree in every respect with Dallas' short but adequate description. I have compared them very carefully with Uhler's description of his *providus* and am compelled to the conclusion that our well known Hemipterist has combined the characters of this species and the common *longiceps* Stal from the United States in forming his *providus*. It is not unlikely however that these really may be forms of one and the same species in which case Dallas' earlier but awkward name will take precedence over those of Stal and Uhler. Dr. Distant has already pointed out the identity of Uhler's species with that of Dallas. I feel inclined at present to follow Baker in placing *Ortholomus* as a genus distinct from *Nysius*.

Ninus notabilis Dist.

One example swept from weeds at Mandeville.

Ischnorrhynchus championi Dist.

This tiny insect was common almost everywhere on the island. I took it most abundantly about Kingston and at Mandeville.

Blissus leucopterus Say.

I watched closely for this insect but found only two examples, both brachypterous. One I took in the railway yards at Kingston, April 17th, and the other in an old banana plantation about a mile south of Constant Spring Hotel. Both are small and proportionately more elongated than specimens from the northern states. It is of course quite possible that they may have been introduced from the United States as they were taken near the principal seaport of the island.

Ninyas Strabo Dist.

This looks like a miniature *Geocoris*. I found it not uncommon toward the western end of the island. It was taken at Mandeville, Balaclava, Appleton and Montego Bay.

Paronius longulus Dallas.

I took a few examples of this widely distributed species at Hope Gardens at Kingston, under a pile of brush and rubbish. I also took it on cultivated lands at Mandeville.

Pamera vincta Say.

Common everywhere I collected in the southern and western districts of the island. Distant now places as synonyms of this species *parvulus* and *gutta* of Dallas, *amyoti* of Guerin, *vinulus* of Stal, and *bipunctatus* of Kirby; thus extending its range to India and Ceylon.

Pamera bilobata Say.

I found this species fairly common at Rock Fort near Kingston, Mandeville, Hope Bay, Troja and Richmond. These specimens were a little smaller and more clearly marked than those I have seen from the United States. They very closely resemble Distant's figure of *Pamera vicinalis* on plate 19, fig. 13 of the Biologia.

Pamera sp.

Mandeville, April 1st, one example. This specimen is somewhat mutilated and I have been unable to place it satisfactorily. It has a broad form and shows some affinities with genus *Ptochiomera* but the clavus is irregularly punctured and I prefer to place it in *Pamera*.

Ptochiomera sp.

St. Margaret's Bay, April 12th, one example. This is a tiny little insect scarcely more than a millimetre in length. It might be mistaken for a *Cligenes* were it not that the sides of the pronotum are not at all carinate. In form it much resembles *Ptochiomera nodosa* but is not half its size and has the apical joint only of the antennæ moderately enlarged.

Ozophora pallescenes Dist.

One example, taken at Hope Bay April 12th, agrees exactly with Distant's figure and description. I have received it also from the island of Trinidad.

Ozophora concava Dist.

I took one example of this species at Gordon Town, March 24th. It would not be surprising should a long series show this and *pallescens* to be forms of a single variable species.

Family Pyrrhocoridæ

Dysdercus mimus Say.

Very abundant at every locality where I collected on the island. I took all variations in size, form and marking as described by Dr. Uhler in his List of the Hemiptera from West of the Mississippi River.

Dysdercus andræ Linn.

Another very common species occurring in great numbers on certain trees and bushes, and frequently coming to light at night. I have this species from Cuba and Mrs. Annie Trumbull Slosson has taken it in Florida.

Dysdercus jamaicensis Walker.

I took this large showy species from the hillside at Port Antonio and at St. Margaret's Bay, Richmond, and at Hope Gardens at Kingston. At Balaclava I took it on a large tree called by the natives "Aaron's Rod." The six individuals taken by me show but slight variation in the extent of the black markings. They differ from Walker's description only in having the rostrum extended to the middle of the third ventral segment. *D. sanguinarius* Stal is an allied species with a longer rostrum and black scutellum.

Family Tingidæ

Corythuca gossypi Fabr.

Many examples of this tiny species were taken at Kingston, Mandeville and Montego Bay. It may readily be distinguished from *spinosa* Champ., which it most closely resembles, by its having the median pronotal carina nearly or quite as high as the hood, which is set well forward.

Corythuca marmorata Uhler ?

I beat numbers of this species from a bush on the bank of a ravine back of Montego Bay. I do not yet feel fully satisfied of its identity with *marmorata*.

Corythaica carinata Uhler.

I took two examples of this queer looking insect by the railroad tracks east of Balaclava on April 5th; several at Kingston, and found it common at Montego Bay on bushes along the roadside near Paradise Pen. Two of those from Kingston are smaller and paler and seem to be somewhat immature. Dr. Uhler described this species from material taken on the island of Grenada.

Leptostyla tumida Champ.

This is one of the most beautiful Tingids that has come under my observation. I swept eight examples from low weeds about a mile east of Rock Fort, Kingston, on March 25th. My specimens correspond in every respect with Champion's figure and description.

Leptostyla angustata Champ.

A pretty little whitish species of which I took five examples at Montego Bay. These differ from the description in the Biologia in having a round blackish spot a little behind the middle of the discoidal area, which is almost obsolete in some individuals and very distinct in others.

Leptostyla constricta Champ.

One specimen of this little species was swept from grass and weeds along the railroad track a little south of the station at Troja. The apical joint of the antennæ is dark brown rather than black.

Leptostyla colubra n. sp.

Form and general appearance of *constricta* Champ. Body black; spines of the head, antennæ, bucculæ, and legs pale testaceous or white. Basal joint of the antennæ about twice the length of the second; third elongated, slender; fourth about equal to the first and second united, darker. Pronotum broad across the subangulated humeri behind which is a distinct transverse impressed line separating the large triangular posterior portion, the extreme tip of which is truncated and slightly emarginate. Anteriorly the pronotum is strongly narrowed; sides with a slender carina which is higher across the anterior sinus; hood moderately elevated; disk strongly, almost tubercularly elevated, as high as the hood, tricarinate; color ferruginous becoming blackish posteriorly; the median carina and a slender line bounding the pale lateral carinæ, black; hood and anterior edge of the pronotum white, the latter with two black points beneath the hood. Elytra fuscous or blackish, the costal area whitish hyaline, broken by a broad black band at the middle and a narrower one at apex, the disk of some of the apical areoles subhyaline; bounding nervures of the discal area white at apex; discal, subcostal and sutural areas finely areolate, the costal and apical areoles larger; costal area indistinctly triseriate. Wings almost attaining the apex of the elytra. Rostrum reaching the insertion of the posterior legs. Length 2 to 2½ mm.

~~Described from 22 examples~~ taken at Mandeville and Balaclava where it appeared to be common. This little species has the form, size and markings almost exactly of *constricta* but may readily be separated by its having the expanded membranous margins of the pronotum reduced to a mere carina; the disk much more convex and divided by a transverse suture, and the posterior tip truncated. The basal joint of the antennæ is also a little shorter and the colors are more varied. Some of these characters might be construed to be of generic value. The specific name is suggested by the dark markings which recall those seen on certain serpents.

Acanthochila armigera Stal.

I took four adults and one larva of this pretty species from the hill south of the Newleigh House at Mandeville, and two adults by the roadside near Paradise Pen at Montego Bay. These are all rather pale ferruginous with the head, apical joint of the antennæ, its base excepted, anterior disk of the pronotum, body beneath and tips of the marginal spines of the pronotum, black. The two long spines on the head are white and conspicuous, and the transverse vitta on the elytra is pale and poorly defined.

Acanthochila spinicosta n. sp.

Closely allied to *armigera* but differing principally in having the costa armed with spines to behind the middle, those near the base longer, and tipped with black as are those of the pronotum; the head ferruginous instead of black; the basal joint of the antennæ with a black line exteriorly, and the apical joint black only on its apical one third. Membranous margin of the pronotum somewhat broader than in *armigera;* disk of the discoidal and subcostal areas conjointly ferruginous, darker than in *armigera*, the intervening carina white at apex with a black dash before the middle.

Lower surface of the head pale, of the body deep black, with the insertions of the coxæ, broad margins of the propleura, legs and rostrum pale. Genital segment ferruginous. Bucculæ white. In *armigera* as known to me the entire lower surface is deep black with the bucculæ white and the rostrum, legs and insertion of the coxæ pale. The spines on the base of the vertex are whitish as in *armigera* but the transverse black band on the anterior lobe of the pronotum of that species becomes paler in this.

Described from one example taken on the borders of a rich cultivated field at Mandeville, April 3d. This species has the form and general appearance of *armigera* but the characters given above will readily separate it. I confess that I do not feel at all certain of the synonomy given by Mr. Champion in the Biologia for *armigera* Stal.

Amblystira maculata n. sp.

Closely allied to *opaca* Champ. Deep black, shining; antennæ, legs and elytra whitish, the latter with a large angulated median black spot, which omits the calloused sutural and apical margins and becomes much narrowed to the costal nervure, along which it runs anteriorly for a short space; the large sutural area is a little enfumed, with black nervures. Antennæ: first and second joints short, subequal in length; third about twice the length of the fourth; apical one third of the latter blackish. Bucculæ narrowly edged with pale. Pronotum obscurely carinate on the sides; disk tricarinate, median carina strong, scarcely attaining the apex of the posterior prolongation, the lateral subobsolete; whole surface coarsely punctate. Elytra with the discoidal area narrow, subcostal finely reticulated in several rows; costal area forming a very narrow margin to the subcostal, beyond that much widened, with one series of large areolæ. Wings smoky toward their tips, with fuscous nervures.

Described from one example taken on the hillside south of Richmond village, April 15th. Differs from *opaca* in color, the shining black of the upper surface, the tricarinate disk of the pronotum, and the large areolæ in the sutural area of the elytra.

Leptoypha binotata Champ.?

Kingston, two examples swept from bushes near the railroad tracks west of the station on April 17th. I feel some uncertainty about this determination as these specimens differ from Champion's description in several particulars. The body is dark ferruginous, not black, beneath; the elytra have a double transverse vitta and the whole sutural area fuscous, with the included nervures black; the discoidal and subcostal areas are confused, and together with most of the sutural area are closely and minutely areolate; costal area very narrow and uniseriate; wings well developed. I have little doubt but further West Indian material would connect these with the darker specimens from the main-land described by Mr. Champion.

Teleonemia sacchari Fabr.

Taken in numbers at almost all places where I collected on the island.

Teleonemia scrupulosa Stal.

Taken with the preceding and equally abundant. I distinguish this species most readily by its smaller size, paler color, the longer pale spines on the head, and particularly by the much wider costal area.

Teleonemia prolixa Stal.

Troja, April 14th, one example. Mr. Otto Heidemann who has determined this species for me and who has very kindly assisted me in the verification of some of the doubtful species of the Tingids thinks this the "*var. a*" of *prolixa* as described by Mr. Champion. This is a larger and darker species than *sacchari*, with a narrower and more sinuated costal margin. I have in my collection a still larger and darker specimen taken by Mr. R. J. Crew near Demerara, British Guiana, April 12th, 1901.

Teleonemia cylindricornis Champ.

This is a larger and paler species of which I took two specimens at Mandeville and one at Hope Gardens, near Kingston, among weeds by a roadside on March 27th. This species is separable from the two preceding by its larger size, longer and stouter antennæ, and by the partially biseriate costal area. It is very close to *variegata* Champ. of which Mr. Otto Heidemann has very kindly sent me an example taken in Arizona. I can separate *cylindricornis* by its having the median pronotal carina distinctly elevated in front and the lateral carinæ almost parallel behind, not distinctly divergent as in *variegata*; and the costal area is much more distinctly biseriate. The antennæ are longer and stouter and the elytra more ampliated, but these characters are less noticeable.

Atheas nigricornis Champ.

Several examples of this species were swept from herbage in a pasture at Mandeville, March 30th. These have the extreme of the third antennal joint paler and the apex of the discal ea of the elytra blackish. In all other respects they agree th Champion's description and figure.

onanthia monotropidia Stal.

Three examples swept from weeds along the road to Parase Pen at Montego Bay, April 8th.

onanthia c-nigrum Champ.

Mandeville, three examples: a large specimen taken on the llside near the Newleigh House, March 29th, and two smaller es from a cultivated field April 3d. These all agree well with ampion's figure and description except that the femora are ncolorous, ferruginous, instead of black.

Family Phymatidæ

ymata marginata Fabr.?

I took one example of this little species from bushes along e roadside in Balaclava village on April 6th. This is a male easuring but five millimetres in length, and differs from the ure and description given by Handlirsch in having the posrior "wings" of the pronotum and the expansion of the conxivum on the fourth abdominal segment less pronounced and ute. They seem to agree in all other essential respects and see no reason to doubt the correctness of this determination.

Family Veliidæ

agovelia Taylorella Kirk.

I found quite a colony of these active little insects sporting the surface of a small stream near the railroad station at roja. In all of these the legs are metallic greenish black, th the trochanters, coxæ, base of the anterior femora and of e other femora beneath, fulvous.

icrovelia pulchella Westw.

One fully winged example that I determine as Westwood's ecies was taken from a rivulet near the road about a mile uth of the Constant Spring Hotel. The elytra in this are ally dull whitish with the nervures broadly fuscous; the portal collum is fulvous, bisected by the blackish median protal line. This individual answers in all respects to the brief scription given by Amyot and Serville except that the elytra are more obscurely white. Dr. Uhler's *M. robusta* would seem to be a very closely allied species.

Near Rock Fort I took from a little pond of water by the roadside a larval form of *Microvelia* that I take to be the young of the present species as it has the same characters of the antennæ and legs. It is blackish above with the collum and a large quadrate spot on the middle of the pronotum and a dot on the connexival margin of the first tergal segment fulvous.

I was much disappointed in not taking more of the aquatic and littoral forms of the Hemiptera in Jamaica. Although I searched diligently wherever I collected near the water I took but this, the *Rhagovelia* mentioned above, and the single specimen of *Buenoa* noticed further on.

Some years ago while collecting at Rivington, N. J. with Prof. C. W. Johnson my attention was directed by him to a colony of *Microvelias* that had their home in a water barrel under some trees. These specimens agree in every respect with Champion's description of his *albonotata*, founded on a single specimen from Guatamala. This differs from Uhler's description of *modesta* in several minor particulars, and for the present at least I prefer to place these northern specimens under Champion's species.

Family Reduviidæ

Ghilianella Signoreti Dohrn.

This large species was not uncommon on trees and bushes in various parts of the island. I have notes of having taken it at Mandeville and Hope Bay. In the specimens brought home the intermediate and posterior legs are no darker than the anterior but show the pale rings on the femora quite distinctly. Two small immature examples from Mandeville and Balaclava are apparently the young of this species.

Ploiariola errabunda Say.

I captured three specimens at Mandeville that I cannot distinguish from this species as found in the United States.

Luteva sp.

One example of a species I have been unable to determine was taken at Balaclava, April 5th.

Pnirontis infirma Stal.

One nymph that I place here was taken at Mandeville, April 1st. The extreme edge of the abdomen has not the black spots mentioned by Stal but that character may depend somewhat upon maturity.

Zelus rubidus St. F.

This was a common insect throughout the island. I took it wherever I collected. I can see no reason for separating this from *Zelus longipes* Linn. Our northern form, *Zelus bilobus* Say, is reasonably distinct in having a longer and more slender head.

Metatropiphorus Belfragei Reut.

One slightly immature example of this interesting insect was swept from grass and weeds at Hope Gardens, Kingston, March 26th. In this individual the elytra are somewhat flaccid, pale, with the nervures fuscous on their base and across the middle, thus indicating the dark bands mentioned by Reuter. In all other characters it agrees exactly with his description.

Nabis sordidus Reut.

A macropterus example was taken near the Constant Spring Hotel and a brachypterous one from the roadside a little beyond Rock Fort.

Nabis ferus Linn.

Two examples from the fields near the Constant Spring Hotel, March 26th. These are a little longer and narrower than examples from further north but I cannot distinguish them specifically.

Carthasis rufonotatus Champ.

I took several examples of this delicate little species at Mandeville and Balaclava. These were beaten singly from trees in open sunny situations.

Family Cimicidæ

Cimex lectularius Linn.

Not an uncommon guest at the hotels in the smaller towns and interior villages.

Family Anthocoridæ

Piezostethus sp.

Numbers of a small species in this genus that I have been unable satisfactorily to determine were taken in various parts of the island.

Triphleps insidiosus Say.

One specimen, certainly pertaining to this species, was taken at Mandeville and two smaller examples that I cannot feel sure are distinct were swept from herbage at Hope Bay.

Cardiastethus fraterculus n. sp.

Fulvous, tinged with rufous in places. Head and prothorax rufo-piceous; the pronotum, excepting the disk of the anterior lobe, and the humeri piceous black with metallic reflections in certain lights. Elytra dull and opake, apical one half of the clavus, disk of the corium, and inner field of the embolium within the longitudinal furrow, fuscous; cuneus blackish. Membrane fuscous with iridescent reflections, the inner margins fulvous at base and pallid toward the apex. Antennæ, rostrum and legs testaceous yellow.

Head short, the prolongation before the base of the antennæ quadrate. Eyes large, granulated. Antennæ: first joint attaining the apex of the head, second longest, clavate and fuscous at apex, third and fourth more slender, dusky, fourth shortest, much shorter than the third; all but the basal armed with long scattering hairs. Rostrum reaching to between the anterior coxæ. Pronotum broad, transverse, strongly narrowed to the front, sides feebly arcuated; surface coarsely punctured, omitting however the large pale disk of the anterior lobe; collum rather narrow, distinct. Scutellum pale, the transverse impression conspicuous. Elytra with scattering coarse shallow punctures; embolium narrow, at apex about one half the width of the corium; nervures of the membrane almost obsolete. Propleura and sutures of the other pleural pieces rufo-piceous. Osteolar canal long, strongly curved and attaining the anterior suture of the mesopleura. Whole upper surface sprinkled with short, stiff, yellow hairs. Length 2 mm.

Described from one example taken at Mandeville, March 29th. This seems to be quite distinct from any species yet described. It answers most nearly to Reuter's description of *Pergandei* but has the short rostrum and feebly sinuated costa, and in his synopsis would go directly to *consors* from New Zealand. It is perhaps still nearer to *assimilis* which has a short rostrum notwithstanding that Prof. Reuter has placed it in his table among those in which the rostrum attains the middle of the mesosternum. From that species however ours may be distinguished by the different sculpture of the pronotum, the deeper impression on the disk of the scutellum, the narrower embolium, and the different coloring.

Termatophylidea pilosa Reut.

Quite a number of specimens of this very interesting species were beaten from bushes and small trees at Mandeville, Balaclava and Montego Bay. Dr. Reuter writes me that this is the first American representative he has seen of this subfamily of the *Anthocoridæ*. He will describe the genus and species, both of which are new, in a paper on the *Termatophylinen* he now has in preparation.

Family Capsidæ

The Capsidæ were well represented among the material taken in Jamaica. The specimens averaged much smaller than those found in the United States and in most cases but few individuals of each species were taken, but this was true of all the Hemiptera I took on the island. Some of these Capsids were very prettily colored and marked and the collection on the whole was an interesting one. Dr. O. M. Reuter of Helsingfors very kindly offered to study these for me and has published the results of this study in the Of. Finsk Vet-Soc. Forhandl. xlix. No. 5, pp. 1 to 27, 1907, to the pages of which paper reference is made after the name of each new genus and species. In this paper Dr. Reuter has described as new seven genera, twenty nine species and two varieties from the material brought home by me. In the nomenclature and arrangement of the divisions, and so far as possible of the genera, I have followed the classification published by Dr. Reuter in the Festschrift für Palmen No. 1, p. 27 et seq., 1905.

Division Plagiognatharia

Psallus atomophorus Reut. (n. sp. p. 22.)

Two examples taken at Rock Fort near Kingston, March 25th. This is a delicate little species of a pale yellow color with a fuscous cloud across the elytra and the whole upper surface dotted with brown points.

Psallus (?) sulphureus Reut. (n. sp., p. 23.)

Taken in numbers along the roadside at Rock Fort. It is a pale yellow species with a black point on the apex of the cuneus and a dot a little behind this on the margin of the maculated membrane.

Reuteroscopus ornatus Reut.

One example of this northern species was taken at Hope Gardens and another near Constant Spring Hotel at Kingston. The generic name *Episcopus*, under which this species was described, being preöccupied Mr. Kirkaldy in 1905 proposed the name *Reuteroscopus*, (vide Reuter) and again in 1906 the name *Aristoreuteria*, the former of which has been adopted by Dr. Reuter.

Atomoscelis diaphanus Reut. (n. sp., p. 24.)

Mandeville, April 2d, one example.

Leucopoecila (Reut. n. gen., p. 24) **albofasciata** Reut. (n. sp., p. 26.)

Rock Fort, March 25th, two examples. This is a little black insect resembling our northern *Chlamydatus* (*Agalliastes*) but marked with a transverse white band on the elytra.

Sthenarus plebejus Reut. (n. sp., p. 26.)

Mandeville, seven examples Balaclava, one example. A shining black little creature with the base of the antennæ and legs pale yellow.

Sthenarus basalis Reut. (n. sp., p. 26.) Mandeville.

Division Cyllocoraria

Jornandes semirasus Dist.

Very abundant at Mandeville and Balaclava and also taken at Richmond. This species looks somewhat like a miniature *Ceratocapsus* (*Melinna*) *modesta* Uhler. Distant's material was from Guatemala.

Zanchisme illustris Reut. (n. sp., p. 11.)

Balaclava, April 5th, two examples. A neat little species with much the aspect of a small *Pilophorus*. This generic name was substituted for Reuter's preöccupied name *Schizonotus* by Mr. Kirkaldy in 1904.

Falconia caduca Dist. var. (Reut. p. 11.)

Mandeville and Balaclava. A pale yellow species with nearly the form of a *Dicyphus*, with the eyes and apex of the scutellum deep black, and the last joint of the antennæ, claval suture and a spot on the base of the membrane fuscous. The type was from Guatemala.

Baculodema (Reut. n. gen., p. 12.) **luridum** Reut. (n. sp., p. 13.)

Balaclava, one example. Looks like a slender *Jornandes.*

Ceratocapsus nigro-piceus Reut. (n. sp., p. 13.)

Balaclava, four examples; Montego Bay, one example. Dr. Uhler described this genus in 1887 as *Melinna* and Mr. Kirkaldy renamed it *Hypereides* in 1903. Dr. Reuter however considers it identical with his genus *Ceratocapsus* published in 1875.

Ceratocapsus consimilis Reut. (n. sp., p. 14.)

Balaclava, one example. This has much the appearance of a small *Ceratocapsus modestus* Uhler.

Orthotylus compsus Reut. (n. sp., p. 14.)

Kingston, one example.

Orthotylus divergens Reut. (n. sp., p. 15.)

Rock Fort, near Kingston, two examples. A pale little species with a red band across the base of the elytra and scutellum and a black membrane.

Platyscytus (Reut., n. gen., p. 16.) **binotatus** Reut (n. sp., p. 17.)

Hope Gardens, Kingston, one example. This is an odd little insect: pale yellow with the scutellum and a round dot on each elytron red.

Melanostictus (Reut., n. gen., p. 17.) **Van Duzeei** Reut. (n. sp., p. 18.)

Balaclava, April 5th, one example.

Hyalochloria (Reut., n. gen., p. 18.) **caviceps** Reut. (n. sp., p. 20.)

Not uncommon. I took it at Mandeville, Balaclava, Montego Bay and Richmond. This is an exceedingly delicate little insect much resembling *Diaphnidia parvula* Uhler from Florida.

Hyalochloria unicolor Reut. (n. sp., p. 20.)

Mandeville, March 31st., one example.

Mesotropis (Reut. n. gen., p. 21.) **viridifasciatus** Reut. (n. sp., p. 22.)

Hope Gardens and Constant Spring Hotel, Kingston, two examples; Balaclava, one example. Another delicate green little species with a band of deeper green across the elytra, which may, however, be almost obsolete.

Division Pilophoraria

Tiryus punctulatus Reut.

Taken at Mandeville, Balaclava, Montego Bay and Richmond. Described in 1875 as a *Trichia* from material taken in the southern United States.

Division Dicypharia

Dicyphus separatus Uhler.

I took numbers of this species from a bush, I think a species of Croton, growing in a garden at Gordon Town, March 24th, and at Rock Fort the next day. Dr. Reuter did not report on this species but my specimens seem identical specifically with others in my collection from Maryland and Florida, and my friend W. J. Palmer took what I believe to be the same species at Lake Temagami, Ontario, (See Can. Ent. xxxviii, p. 407, 1906.) In my report upon these Temagami Hemiptera I listed this species as a *Macrolophus* under which name I had received it from correspondents. I now find that it was described as a *Dicyphus* by Dr. Uhler (Proc. Zool. Soc., 1893, p. 194), from specimens taken in the island of Granada together with material from the United States.

Division Laboparia

Halticus Uhleri Girard.

Common at Mandeville and Balaclava. Dr. Distant has redescribed this species in the Biologia as *Calocoris canus*.

Division Miraria

Collaria oleosa Dist.

A very abundant insect everywhere on the island.

Trigonotylus tenuis Reut.

A delicate little species of which I took four examples at Hope Gardens at Kingston, April 17th.

Creontiades rubrinervis Stal.

This was the largest Capsid taken by me on the island. I found it at Mandeville, Balaclava and Appleton The type specimens were from Mexico. Distant records it from Guatemala and Uhler from St. Vincent and Granada, and Mrs. Slosson has it at Biscayne Bay, Florida. I follow Reuter in placing 'enus in the *Miraria*.

Division Capsaria

ocoris compsocerus Reut. (n. sp., p. 4.)

took two examples of this at Mandeville and two at Balac- It is closely allied to *eximus*.

s apicalis Fieb.

'hree examples taken near the Constant Spring Hotel. is a small green species somewhat resembling *prasinus*. s described by Fieber in his Europäischen Hemiptera from 'ial taken in Spain. I cannot find any previous record of ving been taken in America.

s apicalis var. **inops** Horv.

'ery near the preceding. I found this form at Hope Gar- ınd in numbers at Mandeville.

s aeruginosus Reut. (n. sp., p. 5.)

Iandeville, April 1st, two examples. A shiny little species much the aspect of an *Orthops*.

s olivaceus Reut. (n. sp., p. 6.)

Not uncommon on the southern side of the island. I took r the Constant Spring Hotel, at Mandeville, Balaclava and ego Bay. It looks somewhat like a small compact *invitus*.

s suspectus Reut. (n. sp., p. 6.)

maller and more strongly maculated than the preceding. one example at Rock Fort, March 25th, and another at eville, April 3d.

cunealis Reut. (n. sp., p. 7.)

.andeville, three examples. At Balaclava I took two ex- s of what seems to be a pale form of this species. *lis* is near the preceding species but has the pronotum l, scutellum, clavus and inner angle of the corium piceous

oscytus cuneatus Dist.

ommon about Mandeville and Balaclava. I also took it ck Fort near Kingston. I have received this species from a Guiana and the island of Trinidad and Distant, who described it as a *Lygus*, records it from Mexico and Central America.

Pœciloscytus cuneatus var. **rufu-cuneatus** Reut. (n. var., p. 8.)

Differs from the typical form in being paler with a red cuneus. I found it abundant, particularly about Mandeville.

Pœciloscytus flavo-cuneatus Reut. (n. sp., p. 8.)

Two examples taken at Hope Gardens, March 26th. Very near *cuneatus* of which Dr. Reuter thinks it may prove to be a variety.

Cyrtocapsidea irrorata Reut. (n. sp., p. 9.)

Mandeville, April 1st, one specimen. This is a pretty little species with somewhat the aspect of a small *Phytocoris*. Dr. Reuter records its occurrence in Mexico.

Neoborops oculatus Reut. (n. sp., p. 10.)

Mandeville, April 1st, one example.

Division Clivinemaria

Lamproscytus (n. gen. Reut., p. 3.) **Van Duzeei** Reut. (n. sp., p. 4.)

Mandeville, one example. Looks a little like a small *Pilophorus*. Piceous black with red elytra marked with a large white spot on the membrane.

Division Bryocoraria

Cyrtocapsus caligineus Stal.

Taken at Kingston, Mandeville, Balaclava and St. Margaret's Bay. Not uncommon. Distant records it from California, Mexico and Guatemala and Dr. Uhler from the island of Granada.

Pycnoderes Van Duzeei Reut. (n. sp., p. 1.)

Common at Mandeville and also taken at Balaclava and Kingston. Closely resembles *atratus* Dist.

Pycnoderes angustatus Reut. (n. sp., p. 2.)

A larger and more slender species taken with the preceding and equally abundant.

Bryocoris minutus Reut. (n. sp., p. 2.)

Mandeville, two examples. Aspect of a small *Chlamydatus*.

Neocarnus vitreus Dist.

Common at Mandeville and Balaclava and taken also at Montego Bay and Hope Bay. The types were from Panama.

Family Notonectidae

Buenoa antigone Kirkaldy.

One example, a female eight millimetres in length, was brought into the house at Mandeville with water from one of the cisterns that are everywhere used in that part of the island for the domestic water supply.

Family Fulgoridæ

Subfamily Cixiinæ

Bothriocera Signoreti Stal.

I found this species fairly abundant throughout the island and have received an example from Mrs. Slosson taken at Biscayne Bay, Florida. These specimens do not altogether agree with Stal's description of this or any of the other known species. The fuscous markings on the elytra form a distinct transverse stigmatal band followed by a narrow broken pale vitta, a round subcostal spot, and an apical hyaline vitta; the base and sides of the vertex and the tegulæ are also pale. One smaller example from Balaclava seems to approach *bicornis* Fabr.

Bothriocera undata Fabr.

One example taken at Mandeville, April 1st.

Oliarus complectus Ball.

Apparently common throughout the island. These specimens were somewhat smaller than those taken in Ohio, Colorado and at Washington, D. C., now in my collection, but they seem to be otherwise identical.

Myndus crudus n. sp.

Form of *sordadipennis* nearly; a little smaller with a narrower vertex and less expanded front. Color a uniform soiled white. Carina of the head and marginal nervure of the elytra tinged with yellow, the latter slightly embrowned around the apex of the membrane; discal nervures of the elytra slender, whitish, setigerous-punctate; stigma scarcely differentiated. Extreme tips of the tibial spines and tarsal claws black. The anterior margin of the mesonotum has a black cloud that shows through the pronotum but is mostly hidden by the posterior margin of the head. Eyes black; ocelli orange. Tergum in one female slightly embrowned at base and along the median line. Length to tip of the elytra 5 mm.

Described from two examples taken at Hope Bay, April 13th, and one from Troja taken the next day. These insects have the appearance of being immature but on careful examination I believe they have attained their full coloring. If a deeper color is attained later it is possibly a light green as this color is faintly indicated in one example. This species bears some resemblance to *radicis* Osborn but the vertex is shorter and less angled before, the eyes are much more deeply excavated below, the pronotum is narrower, the front is less angled at apex, and the whole insect is smaller and slighter.

Brixia fulgida n. sp.

Size and form of *Cixius pini* nearly. Pale testaceous yellow; narrow elongated disk of the pronoton either side of the middle and the scutellum, its extreme tip excepted, brilliant metallic green; elytra entirely hyaline, slightly tinged with smoky and exhibiting brilliant green reflections by oblique light; nervures brown, the marginal, especially on the costa, heavy and fuscous. Tergum mostly black. Slender edges of the facial carinæ, basal joint of the antennæ, broad inferior margins of the clypeus, lineations of the femora and the anterior and intermediate tibiæ and tarsi, fuscous or black. Length to tip of the elytra 5 mm.

Described from two examples taken at Mandeville on March 30th, from pimento bushes. In this species the vertex is narrow, almost linear, but a little widened at base. So far as I am aware this is the first recognition of genus *Brixia* from America. Its nearest American representative is *Paulia opposita* Fabr. which possesses the same brilliant green coloring on the scutellum. In both my specimens the apex of the abdomen is wanting.

Brixia fuscosa n. sp.

Form and size of the preceding. Pale testaceous brown; metanotum, abdomen in large part, some spots on the pleuræ and the disk of the front black; clypeus, carinæ of the face, pronotum and scutellum, sides of the prothorax, edges of the pleural pieces, and the legs paler; the latter with some lineations and the tarsi, darker or fuscous. Antennæ brown, basal joint whitish. Elytra hyaline, slightly enfumed, exhibiting metallic green reflections by oblique light; nervures, about three spots on the transverse nervures at the base of the membrane, and a marginal cloud at the tip of each apical nervure, fuscous; marginal nervure strong, interrupted with white on each side at the first row of transverse nervures. Length to the tip of the elytra 5 mm.

Described from a single specimen taken at Mandeville, March 31st. This species is closely allied to the preceding but is very distinct in color and has the front broader above and the pronotum wider.

Subfamily Tropiduchinæ

Tangia sponsa Guer.

Three examples, taken at Mandeville, Balaclava and Hope Bay. This is a broad species of a pale yellowish green color with the head triangularly produced, obtuse at apex, about as long as the width of the head across the eyes. Elytra with a broad costal membrane crossed by numerous oblique veinlets.

Tangia cultellator Walker.

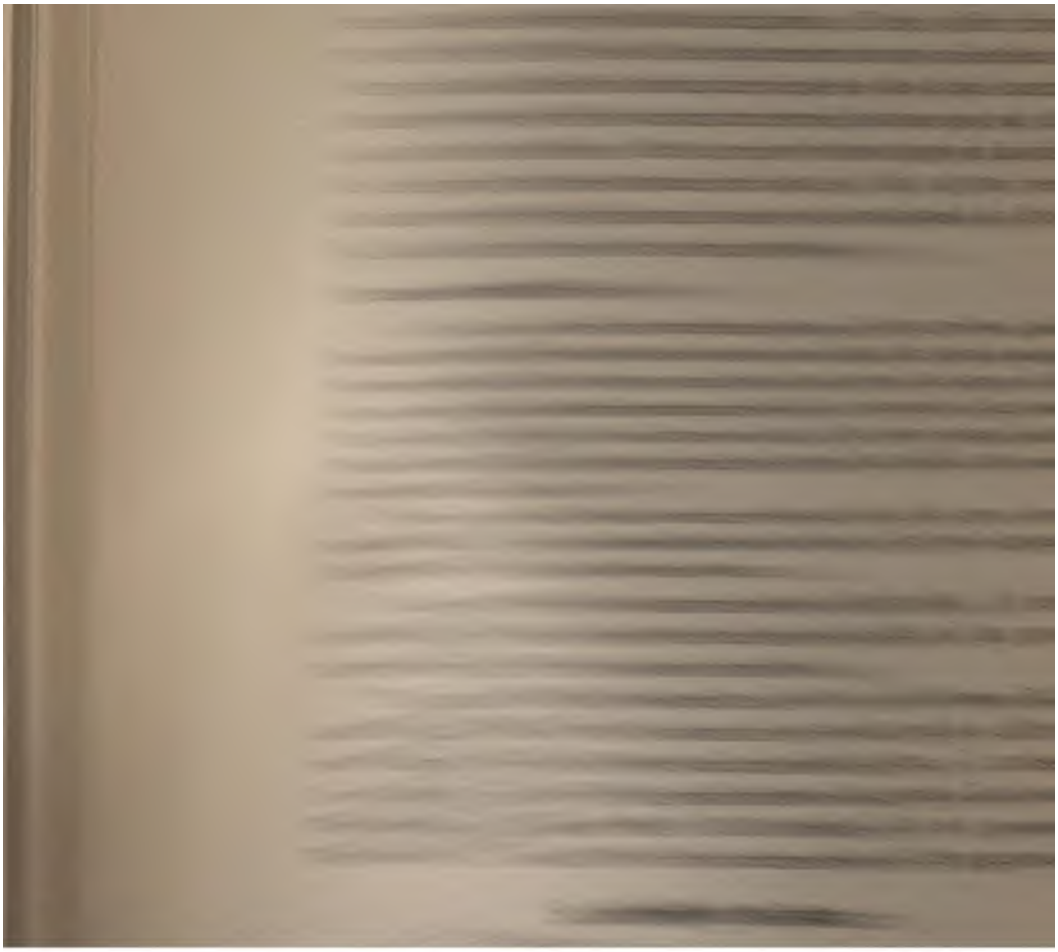
Taken at Kingston, Montego Bay and Hope Bay. This is a slender light green species with the head drawn out in a long slender and linear process fully twice as long as the width of the head across the eyes. The elytra are narrow with the whole surface of the areoles minutely papillate; costal membrane very narrow. This species closely mimics a *Dictyophora* in which genus it was placed by Walker. The type came from St. Domingo.

Subfamily Achilinæ

Catonia intricata Uhler.

Three examples taken at Mandeville, April 3d. Two smaller and darker specimens, probably males, have the rufous tinge at the apex of the costal area quite pronounced, and agree perfectly with a specimen determined as *intricata* by Prof. Ball and kindly sent to me for comparison by him. One larger specimen has the white granulations of the elytra much more distinct. In all there is a dark cloud at the base of the clavus bounded behind by a whitish transverse spot, and the wings are dark smoky brown with fuscous nervures.

At Mandeville I took one example of a very pretty and interesting representative of this subfamily which unfortunately had its head eaten off by ants so it is impossible for me to locate either the genus or species, both of which I believe are new. It is a short compact little fellow, 4 mm in length, convex above, oblong in form, of a piceous brown color with the claval region closely dotted with white and with an oblique white line at the base and another at the apex of the costal area.



more deeply sinuated that in *sinuata*. Front longer and much narrower above, the sides almost angled below, margins sharply reflexed, median carina distinct, either side of which is an arcuated pale line simulating an intermediate carina. Pronotum about as long as the vertex, strongly produced anteriorly in an obtuse angle between the eyes, the sides behind the eyes very short. Scutellum with three parallel longitudinal carinæ and an abbreviated oblique one on either side which meet at the anterior end of the **median** carina and are subparallel with the fore border of the pronotum. **Elytra** surpassing the abdomen by nearly one half their length, almost linear, the costa a little expanded near their base; inner ulnar nervure forked beyond the middle, outer ulnar and radial nervures simple; transverse nervures numerous, less so on the clavus and costal area, membrane more irregularly reticulated. Legs short, posterior tibiæ simple. Antennæ short, about as in *Cixius*; first joint very short, second longer, subglobose.

Color light fulvous brown, sometimes darker on the front, middle of the scutellum and elytra, the latter with the costal area and clavus pale, apical margin and a spot beyond the tip of the clavus fuscous; carinæ of the face, pronotum and scutellum paler, apex of the clypeus, base of the second antennal joint, a spot behind the eyes, sides of the genital pieces and tarsal claws black; two transverse bands on the anterior femora, a longitudinal ray on either side of the apex of the front and some marks on the abdomen dark brown. Eyes dark brown or black; ocelli amber yellow.

Described from numerous examples. This insect was abundant everywhere on the island, especially on Lantana bushes. It exhibits considerable variation in the depth of coloring but it is quite distinct in its structural characters from Mexican material I determine as Burmeister's *sinuata*, and from Canon Fowler's figure of that species in the Biologia. I cannot find that Burmeister's genus or species have either of them been properly described and I have therefore included most of the generic characters in the above description. Dr. Melichar now places this genus in the *Ricaniinæ*.

Subfamily Flatinæ

Amphiscepa plana n. sp.

Much smaller than *bivittata*. Of about the same shade of green over the whole insect; a narrow dorsal line, sometimes almost obsolete, and the costa slenderly pale or whitish; orbits of the eyes, ocelli and tip of the first antennal joint whitish; tibiæ toward their apex and the tarsi, a series of concentric linear marks along the commissural and apical margins of the elytra and the oviduct of the female, brown.

Front longer and more nearly parallel above than in *bivittata*. Pronotum shorter at the sides and longer on the middle, anterior margin more produced before, subconical and overlapping the base of the vertex, hind margin almost truncated, not emarginate as in *bivittata*. Scutellum with a small, abrupt and acute pale apex. Elytra narrower, costa not strongly rounded, almost straight for a space along the middle; nervures strong, darker green. Length 5 mm.

Described from five examples taken at Rock Fort, March 25th. This pretty little green species is very distinct from our northern *bivittata*. *Amphiscepa cartilaginea* Stal from Brazil is about the size of this species but is sufficiently distinct in having maculated elytra, a feebly tricarinated front, and the vertex separated from the base of the front by a transverse carina, not rounded as in this species and *bivittata*.

Acanolonia Servillei Spinola.

One example taken at Appleton, April 9th. This is the largest Fulgorid I took on the island. It was swept from rank vegetation growing along the Siloah River.

Orminis contaminata Uhler?

Montego Bay and Hope Bay, five examples. These do not agree well with Dr. Uhler's description and Prof. Ball thinks them distinct. I have not however enough related material to warrant me in describing them as new.

Ormenis ? albipennis n. sp.

Aspect of *septentrionalis*. Smaller; elytra closely reticulated almost to the apex, with but one row of stronger transverse nervures and these frequently not prominent; inner angle acute and slightly falcate; costa more broadly expanded at base, the costal membrane somewhat narrower with the transverse nervures less oblique. Characters of the head, pronotum and scutellum practically the same as in *septentrionalis*. Length 10 mm.

Color clear green, paler in one example that probably is immature; slender costal, apical and commissural margins of the elytra as far as the tip of the clavus, apex of the tibiæ, tarsi, and edges of the genital segments, brown; the costal nervure within this brown line narrowly pale. Wings white with green nervures.

Described from two examples; a dark yellowish-green specimen from Mandeville, and a paler whitish-green individual taken at Richmond.

Ormenis ? albipennis var. brevis n. var.

A smaller form measuring 8 mm, with the elytra proportionately shorter and its hind angle not at all falcate, about right-angled, was taken by me at Kingston, Mandeville, and Hope Bay. In most of these the venation ef the elytra is somewhat indistinct with the transverse nervure scarcely discernable. Possibly these should not be considered as a distinct variety even, but the characters given seem to be constant.

Ormenis ? herbida Walker? (List of Homoptera p. 470.)

Form of the preceding species but smaller with the hind angles of the elytra more produced and falcate. Pale green, each elytron with three black points, a pair placed obliquely before the middle and near the claval suture, the third about midway between these and the truncated apex; the numerous areoles toward the apex of the elytra more or less conspicuously marked with brown, those about the apical margins forming a regular series of longitudinal brown lines which become radiating at the angles; sometimes a few of the smaller areoles on the disk or toward the base are also touched with brown; tips of the tibiæ and the tarsi and sometimes the cheeks washed with brown.

Vertex very short, reduced to a thickened carina across the front of the truncated pronotum. Front transverse, the rounded sides strongly reflexed and more or less embrowned, median carina strong above, becoming obsolete before the clypeal suture; this suture strongly impressed and nearly rectilinear. Pronotum rather long on the middle, fore margin roundedly truncated, hind margin sub-angularly concave, sides about half the length of the middle line. Scutellum with a prominent median carina, the lateral carinæ scarcely indicated. Elytra narrow, costa almost rectilinear beyond the basal third, the costal membrane of nearly uniform width, with strong, close-set transverse nervures; apex straight or slightly concave, outer angles a very little rounded, inner angles subacutely prominent or falcate. Length 5 to 8 mm.

Description made from twelve examples taken at Kingston, Mandeville, Balaclava, Appleton, Montego Bay and Hope Bay. This species seems to be common on the island of Jamaica. It shows much variation in size and extent of the brown markings in the elytral areoles. The three black points on the disk of the corium seem to be constant although in some examples they become much reduced. One large individual shows a brown line on the claval commissure

This insect agrees in every respect with Walker's description of his *Poeciloptera herbida* except in two points: He says the middle chest is "concave behind" which is not true of any species of this family unless he means that the sides posteriorly are concavely arcuated. He also describes the fore wings as "rounded at the tips". He may have meant that the apical angles were rounded. which is partially true and is a somewhat variable character; or it is possible that his specimen was slightly mutilated. His material was from Jamaica and it seems to me quite likely that this is the species he had before him. If, however, it proves to be distinct I would propose the name **tessellata** for the present form.

Cyarda Melichari n. n.

(*Cyarda punctata*, Melichar, Monog. Acan. und Flatiden, p. 135, pl. 7, fig., 17.) This species is well described and figured by Melichar in his Monograph as cited above. It was common all over the island and especially about Kingston where I beat it from Lantana bushes.

I confess I cannot understand how Stal came to locate Walker's West Indian species of *Elidiptera* (*punctata*, *guianæ*, *punctifera* and *debilis*) in *Cyarda*, especially as he is supposed to have made his synonymical notes directly from Walker's type specimens at the British Museum. Walker's descriptions, in part at least, refer to a *Dascalia* mentioned further on. These describe a broad winged form and cannot possible be so construed as to apply to a *Cyarda*. Dr. Melichar has evidently followed Stal in this synonomy, and, as he has well described and figured the species I think it quite appropriate that it should bear his name. *Cyarda difformis*, Walker's type species from St. Domingo, seems to be quite distinct from this as does also *acuminipennis* Spinola which is also figured by Melichar. Stal certainly had no warrant for placing *acuminipennis* as the type of this genus unless he considered it to be identical with *difformis* Walker, nor had he the right to place his own name as authority for this genus. Walker's discription of the genus was amply sufficient for its recognition and *difformis*, being the only species recognized by Walker, must be used as the type. I have received what I believe to be *Cyarda Melichari* from Florida.

Eurocalia n. gen.

Allied to *Neocerus* Melichar. Head with the eyes a little narrower than the pronotum. Vertex short, transverse, truncated before. Front about as long as broad, basal margin almost rectilinear, or very slightly angularly concave, sides below rounded to the straight clypeal suture. Pronotum subcrescentic, obsoletely tricarinate. Mesonotum moderately elevated, the flattened disk bounded by distinct carinæ. Elytra about twice longer than the width of each, narrowed posteriorly to a rounded apex, commissural margin straight; costal membrane much expanded toward the base, about three times the width of the costal cell, its transverse nervures numerous, mostly simple, along the middle more or less united by a supernumerary longitudinal nervure which runs close to the costal; longitudinal nervures strong, united beyond the middle by numerous weaker transverse veinlets; the costal nervure continued across as a single subapical line beyond which most of the longitudinal nervures are once forked; no obvious second subapical line; clavus with some weak reticulations toward the apex, its

base granulated; gibbous knob at the base of the ulnar nervures minutely granulated and there are a few scattering granules on the base of the costal membrane. Posterior tibiæ bispinose.

Eurocalia collaris n. sp.

Pale greenish testaceous tinged with fulvous brown in places especially across the anterior margin of the head and toward the apex of the elytra; a dark brown collar occupies the declivous anterior margin of the mesonotum and there is an elongated mark of a paler brown color along the commissural margin of the clavus; two approximate points near the anterior margin of the pronotum, a minute line on the tegulæ, and a slender oblique line near the base of the radial nervure, black; two distinct points close to the anterior margin of the vertex, a dot behind each eye, two larger spots on each latero-posterior margin of the mesonotum, a round dot toward the base of the corium close to the claval suture, and two larger spots on the apical third of the corium near the commissural margin, the posterior of which tends to form a broken vitta along the subapical line, dark brown. Spines of the tibiæ and tarsi tipped with black.

Vertex very short, its anterior margin a little elevated, almost carinate, a little sinuated across the middle. Front with three short basal carinæ feebly indicated, the lateral very oblique and placed near the margins which are quite strongly reflexed; apex with a transverse brown cloud next the depressed clypeal suture; viewed from the side the front is quite strongly bent inward and almost horizontal beyond the middle. Pronotum with a very obtuse median carina which may be traced as far as the middle of the mesonotum, the lateral carinæ scarcely indicated, exterior to these lateral carinæ the surface is pitted with brown. Costal margin of the elytra slightly sinuated before the narrowly rounded apex. Wings smoky with strong nervures. Length 10 mm.

Described from one example taken at Hope Bay, April 14th. This species will not fit into any genus described by Stal or Melichar although it comes very near *Neocerus* of the latter author. It is not impossible that some of the species described by Melichar under *Dascalia* might be placed here. His limitation of that genus does not seem to me to be altogether the same as that intended by Stal.

Dascalia grisea Fabr.

Dascalia grisea Fabr. Stal Hemip. Fabr. ii, p. 112.
Elidiptera punctata Walker, List of Homop. ii, p. 332, 1851.
Elidiptera guianæ Walker, List of Homop. ii, p. 333, 1851.
Elidiptera punctifera Walker, List of Homop., Supl. p. 71, 1858.
Flatoides lichenosus Melichar, Monog. Flat. pt. 2, p. 222, 1902.

I think there can be no question as to the correctness of the above synonomy. *Dascalia acuta* Uhler (Proc. Ent. Soc. Wash, iv, p. 514, 1901.) is a very closely allied species if it be not identical, and we may have to add to this synonomy *Elidiptera* *occidentis* Walker (List of Homop, ii, p 331, 1851.) This seems to be a common species through the West Indies and southern Florida. I beat three specimens from bushes along the roadside beyond Rock Fort near Kingston, March 25th and one more at Hope Gardens on April 17th.

Melichar seems not to have recognized this species as he has redescribed it as *Flatoides lichenosus.* He makes *Poeciloptera sinuatipennis* Stal the type of *Dascalia,* but it seems to me it would have been better to have taken the first species mentioned by Stal as the type. That would have made the typical group include those species allied to *grisea* in which the apex of the elytra are rounded and the costa straight, in place of those with truncated vertex and sinuated elytra.

Flatoides ? monilis n. sp.

Near the preceding but paler and more depressed in form with a narrower head and much longer pronotum. Head much narrower than the pronotum. Vertex hardly half the length of the pronotum; short conical; its anterior and posterior margins nearly parallel; its disk strongly depressed before the obtuse apex and less conspicuously so either side. Front long, ovate, one and one half times as long as broad, broadest opposite the lower angles of the eyes, its base angularly prominent, polished; the disk quite strongly depressed leaving the margins, including the apical, prominently reflexed; clypeus long-triangular with its narrow base straight. Pronotum narrow, strongly produced, the narrow rounded apex advanced before the anterior angles of the eyes, posterior edge moderately concave, not nearly reaching the posterior line of the eyes; disk with a broad longitudinal depression either side of the middle leaving three very obtuse slightly divergent carinæ. Mesonotum rather small, the disk flat and bounded either side by a low carina. Elytra ample; rather more horizontal than in *Dascalia grisea*, almost parallel sided; costa a little wavy before the tip which is rounded; costal membrane about three times the width of the costal areole, with numerous simple transverse nervures; longitudinal nervures strong, transverse veinlets rather indistinct, forming about one subapical line which is not very prominent; no transverse nervures in the costal areole, a few faint ones in the clavus. Posterior tibiæ bispinose. Base of clavus tuberculate.

Color pale greenish grey, darker on the pro- and metanotum and base of the elytra. Tubercular base of the front, vertex, longitudinal depression on the pronotum, and sides of the mesonotum, brownish; anterior submargin of the pronotum with a row of about eight or ten black points on either side behind the oblique carinate anterior edge; ocelli large, set in a red annulus. Elytra pale greenish, subhyaline, faintly clouded with smoky toward the apex; a broken submarginal commissural line on the clavus, a dot near the base of the clavus and about three smaller ones on the tubercular base of the elytra, black; a few intra-venal dots around the apex and a suggestion of a wavy transverse line before the subapical line, brown. Length 10 mm.

Described from one example taken at Mandeville, April 3d. This is quite different from any other *Flatoides* known to me and should perhaps form the type of a distinct genus.

Subfamily Delphacinæ

Copicerus irroratus Schwarz.

Not uncommon on various parts of the island. I took them in greatest numbers at Mandeville and Balaclava but also found them about Kingston and at Troja. These are rather dark in color with the sides of the pronotum and scutellum embrowned. A larva taken at Balaclava is whitish, dotted with fuscous on the thorax, wing pads and legs.

Stenocranus (?) **saccharivorus** Westw.

I took several examples of this insect at Mandeville and others at Balaclava, and at Richmond I swept them in numbers from a coarse grass-like plant that might have been a dwarf cane escaped from cultivation. Unfortunately these were mostly destroyed by the ants on the journey home but enough were left to show well the peculiar characters of the insect. It has much the aspect of a diminutive *Dictyophora*. I hardly believe this can be retained in genus *Stenocranus*. It seems to me much nearer *Tropidocephala* and may form the type of a new genus.

This is a pale green insect with the elytra long, subhyaline, a little embrowned along the inner margin toward the apex, with the nervures green. The vertex is narrow, long conical and produced about one half its length before the eyes. Front narrow, slightly but regularly widened toward the clypeus, with a prominent median carina; viewed from the side the apex is distinctly, subangularly, deflected before the eyes. Ocelli brown. Antennæ conspicuously lineated with black anteriorly. Length to tip of the elytra about 5 mm.

Peregrinus maidis Ashm.

Appleton, April 9th, one example. Mr. G. W. Kirkaldy founded this genus in 1904 (Ent. xxxvii, p. 175) for the reception of the present species. He reports it as found throughout Queensland and on Hawaii. The types were from Florida. The present specimen I swept from vegetation along the Siloah River but its home was doubtless on the sugar cane which was largely grown all along the river.

Macrotomella n. g.

Form broad and stout. Head broad, considerably narrower than the mesonotum. Vertex short, strongly declivous, rounded to the base of the front. Front broad; middle keel forked for its entire length the two branches passing over on to the vertex where they are curved outwardly and meet the lateral keels at the hind margin; clypeus tricarinate. Antennæ short, basal joint not longer than broad. Pronotum tricarinate, about as long as the vertex, truncated behind, lateral carinæ very oblique, straight, reaching the hind edge much exterior to the scutellar carinæ. Scutellum rather short, tricarinate.

This genus seems to be most nearly related to *Jassideus* but the vertex is not at all five angled, being truncated before, and the lateral carinæ of the pronotum attain the hind margin. All the carinæ are strongly distinguished.

Macrotomella carinata n. sp.

Yellowish testaceous; carinæ of the head, pronotum and scutellum white, bordered with black; deflexed sides of the pronotum deep velvety black narrowly edged with white; pleural pieces with some brown spots. Legs lineate with brown which becomes black on the outer face of the tibiæ. Abdomen black marked with pale on the venter. Elytra whitish hyaline; nervures slender punctured with brown, the apical margin slenderly brown. Wings almost as long as the elytra, whitish hyaline; apical nervure brown, discal slender and white.

Vertex almost square, scarcely surpassing the eyes; carinæ very prominent, basal fovæ obsolete but in their place a short median carina. Front broad, sides well rounded, disk divided into three almost equal compartments by the forked median carina. Median carina of the pronotum continuous with that of the vertex; lateral running parallel with the hind margin of the eyes. Sides of the scutellum rather deeply arcuated; lateral carinæ moderately divergent. Elytra but little longer than the abdomen. Oviduct of the female not exceeding the pygofers, pale.

Described from four macropterous females taken at Rock Fort near Kingston, March 25th.

Pissonotus delicatus Van Duzee.

This species was described from a single brachypterous female from California. Later I received a fine series of macropterous and brachypterous females from Mr. Howard E. Weed taken at Agricultural College, Miss., and have myself taken the brachypterous females at Grand Junction and Pueblo, Colorado, Riverton, N. J. and Washington. D. C. All those from Colorado and Mississippi have the apex of the head concolorous, the basal joint of the antennæ in part black, and the femora lineated with brown. Those from New Jersey are darker in color with the abdomen piceous, but do not differ otherwise. The single specimen I took at Washington has the basal joint of the antennæ pale and the apex of the head black. While in Jamaica I took two brachypterous females at Balaclava and one at Mandeville that have the basal joint of the antennæ pale and the apex of the head piceous as in the Washington specimen. All these females I believe to be but variations of one species. I also took at Balaclava and about Kingston five examples of what I take to be the brachypterous male of this species. These are piceous black, a little paler on the elytra, which are broadly bordered with white at apex. The antennæ, legs, coxæ in part, and the apex of the front are testaceous-yellow with the femora and tibiæ lineated with fuscous. The genital segment is large with the aperature oval and vertical, broadest below, with the basal angles deeply excavated leaving a prominent ventral tooth either side; the plates are difficult to make out but seem to be short, ligulate, slightly curved and reaching about half way to the anal tube. Another male taken with these is macropterous. This has the extreme tip of the scutellum white, the elytra whitish hyaline clouded with smoky at base, the nervures pale testaceous and distinctly punctate, the marginal heavy and fuscous, and on the apex of the clavus is an indefinite brown spot.

I took single examples of two other species of *Pissonotus* but I have been unable to locate the species with this material.

Chloriona nigrifrons n. sp.

Pale testaceous yellow; carinæ mostly white. Eyes, front, cheeks, sides of the clypeus, a few small spots on the pleural pieces, claws, a mark on the apex of the clavus, the apical margin of the elytra, some marks on the tergum and the sides of the oviduct, black.

Vertex rather long, quadrangular, extending for about one third its length before the eyes, basal fovæ obsolete. Front narrow, a little wider below, carinæ pale. Antennæ short, basal joint about half the length of the second. Pronotum short deeply emarginate behind, lateral carinæ strong, curved, parallel to and near the hind margin. Scutellum short, the sides deeply sinuated with the apex large. Elytra reaching the apex of the sixth tergal segment; nervures strong, punctate, the commissural white alternated with black at the apex of the clavus.

Described from one brachypterous female taken at Rock Fort near Kingston, March 25th.

Liburnia seminigra Stal.

Rock Fort, March 25th, six examples; Mandeville, March 31st, two examples. These are all males and agree entirely with Stal's short description except that in some the frontal fovæ are fuscous or black and the base of the tergum is orange yellow. Two males taken at Biscayne Bay, Florida, by Mrs. Slosson differ only in having the abdomen, its apex excepted, fulvous. At Rock Fort I took with the above males one brachypterous female that I believe belongs here. This agrees with the males in all structural details but it is larger (2 mm.) and entirely pale testaceous tinged with yellow, with the frontal fovæ and sides of the tergum embrowned. The base of the tergum is fulvous as in the male; the elytra are faintly smoky hyaline with the marginal nervure white; oviduct black.

Liburnia Andromeda n. sp.

Allied to *seminigra* but smaller and more brightly colored. Head, pronotum and scutellum entirely black, polished; clypeus, breast, metanotum and base of the tergum and elytra, orange; narrow posterior and lateral edges of the pronotum and extreme tip of the scutellum white; basal joint of the antennæ black, second whitish. Legs pale yellow; apex of the posterior femora and base of the tibiæ embrowned. Elytra reaching the middle of the tergum, pellucid, tinged with orange at base and white toward the apex, marginal nervures fulvous, becoming fuscous around the apex and on the commissure behind the scutellum. Tergum orange at base, black across the middle and on the sides, pale yellow at apex. Venter mostly orange, black at apex.

Vertex almost square, scarcely projecting before the eyes. Front rather broad, a little narrowed above, disk transversely a little convex, carinæ not strongly differentiated. Pronotum short, lateral carinæ curved behind the eyes. Scutellum a little longer than the pronotum, lateral carinæ widely divergent, sharpely defined. Aperture of the pygofers regularly oval as in [illegible] constricted dorsally by the lateral teeth which are broad and not prominent, ventral notch shallow, obtuse; styles slender strongly arcuated at apex, plates narrow below, angularly truncated at apex. Length [illegible] mm.

Described from two brachypterous males: one taken at Mandeville and one collected by Mr. R. J. Crew near Demerara, British Guiana, April [illegible]. The latter specimen has the abdomen almost entirely orange.

Liburnia Teapæ Fowler.

Biol. Centr. Am. Hom. [illegible]

Taken at Kingston, Mandeville, [illegible] and Hope Bay. This is a very black [illegible] of the antennæ and legs testaceous [illegible] examples which exhibit [illegible] the length of the wing on the elytra. In some [illegible] with a small [illegible] area on the costa beyond the middle. In the other extreme the elytra are hyaline with a fuscous ray through the middle from base to apex toward which it is more or less extended inwardly, nervures punctate.

The only female in the lot differs in being fuscous in place of black, with the narrow edges of the pleural and ventral segments, hind edge of the pronotum, carinæ of the vertex, pronotum and scutellum, and the cheeks, pale. Antennæ and legs yellow as in the male.

Liburnia albolineosa Fowler. (Op. cit. p. 135, pl. 13, fig. 14.)

I took three examples of this pretty species at Kingston. Two of these were swept from a patch of a fine grass growing in a damp railroad ditch. Fowler's description of this species is very inadequate but his figure is excellent and leaves little question about the identity of the species. There seems to be much variation in the amount of black on the elytra. In one example the whitish hyaline areas on the clavus and apex of the costa are so extended as to cover most of the surface. In all my specimens the deflected sides of the pronotum are pale yellow and the frontal carinæ are blackish for most of their length.

Liburnia culta n. sp.

Allied to *pellucida*. Black, somewhat polished; facial carinæ, slender margin and carinæ of the pronotum, apex of the scutellum, commissure of the elytra on the basal half of the clavus; basal foveæ of the vertex, carinæ and slender margins of the scutellum, nervures of the elytra in part, antennæ and legs, testaceous.

Vertex as in *pellucida*, almost square, scarcely produced before the eyes, rounded to the front, the apical triangular fova more acute and elongated. Front narrow, sides almost parallel, foveæ deep black; second joint of the antennæ hardly longer than the first, scarcely expanded, almost smooth. Pronotum as long as in *pellucida*, the lateral carinæ less oblique, the included area more or less invaded with white. Scutellum a little shorter, more convex, with a more slender apex and less distant carinæ. Elytra almost hyaline, a little smoky toward the base and interiorly at apex, the nervures mostly pale becoming blackish along the disk of the corium and toward the apex of the clavus, punctate and forked as in *pellucida*. Abdomen piceous, touched with pale along the margins and on the edges of the segments in places; the metapleura largely pale. Length to tip of the elytra 3½ mm.

Described from two macropterous females swept from a cultivated field at Mandeville, March 31st.

Another form that I believe to be the brachypterous form of the above I took in both sexes at Rock Fort near Kingston, March 25th. These are tiny little things measuring scarcely more than a millimetre in length. In the color and characters of the vertex, pronotum, scutellum, antennæ and legs they agree with them exactly except that the lateral carinæ of the pronotum are much more strongly divergent as is usual in the brachypterous forms. The elytra, which are considerably shorter than the abdomen, are smoky with the margins whitish hyaline interrupted by a conspicuous black mark on the apex of the clavus, and with the hyaline border sometimes expanded over the basal field of the clavus. In the solitary female example the elytra are nearly hyaline with a fuscous cloud following the claval suture and returning around the apical margin, and the lower surface of the abdomen is mostly testaceous-yellow. It may seem strange to place this insect as the brachypterous form of a species nearly twice its size and I do so with some misgivings, but most of their characters are similar and the moist mountain habitat of the larger form may account for the difference in size.

Liburnia humilis n. sp.

Macropterous form: Pale brownish testaceous. Eyes, tarsal claws, oviduct of the female and abdomen of the male in large part black; elytra subhyaline, nervures testaceous becoming fuscous toward the apex. Vertex subquadrate, deflected before, basal foveæ hardly distinguished, apical very small. Front moderately wide, a very little broader toward the apex which is feebly angularly emarginate at the clypeus. Antennæ rather long; second joint much longer and broader than the first, distinctly crenulated on the edges, apex of the first joint slightly embrowned. Pronotum short with the hind margin strongly, angularly concave, lateral carinæ strongly curved. Scutellum large, deeply sinuated on the sides, lateral carinæ nearly parallel, placed near together, tip broad and obtuse. Elytra as in *pellucida*. Length to tip of the elytra 3 mm.

Brachypterous form: similar to the macropterous but with the front somewhat broader toward its apex and the lateral carinæ as usual more strongly divergent. Length 2 to 2½ mm.

Pygofers of the male quite deeply excavated below, the sides sinuated; plates broad, strongly arched and almost meeting above near the anal tube.

Described from five macropterous examples representing both sexes taken at Mandeville, and seven brachypterous specimens from Rock Fort. This plainly colored little species may be distinguished by the large tibial spur, the broad straight uncolored front and the large second antennal joint.

Liburnia terminalis n. sp.

Macropterous form: Pale fulvo-testaceous; carinæ of the head, pronotum and scutellum pale, the median conspicuously whitish; cheeks, clypeus and frontal fovæ fuscous bordered with black next the pale carinæ, or their entire surface may become blackish. Apex of the first antennal joint and sometimes the base of the second conspicuously black; abdominal segments edged with black. Elytra somewhat narrower than in *pellucida;* hyaline, the punctured nervures pale becoming fuscous toward the apex. Head broad; vertex short, apical fova small; front well narrowed between the eyes, sides subparallel below; first antennal joint slender, about three fourths the length of the second. Length to tip of the elytra 3 mm.

Brachypterous male: Similar to the macropterous but with the front a little wider and paler and the lateral carinæ of the scutellum more oblique. Length 2 mm.

Pygofers of the male roundedly excavated below, the sides scarcely sinuated; plates rather short, ligulate, almost parallel or feebly divergent, somewhat incurved at apex against the margin of the anal tube.

Described from eight macropterous and one brachypterous example, all from about Kingston. One of the males has the abdomen almost entirely black. I took at Mandeville two other brachypterous females that I do not like to place with either of these species although they seem to be very closely allied to *humilis.*

Liburnia ? reducta n. sp.

Macropterous female: Pale testaceous yellow; vertex, face, antennæ and legs brownish; carinæ of the head, tip of the second antennal joint and margins of the eyes paler. Pronotum and scutellum with a broad median vitta bisected by the pale median carina, and a broad lateral vitta behind the eyes, piceous brown. Abdomen and pleural pieces pale marked with dark brown, the tergum trilineate with pale brown; oviduct black; mesopleura with a lateral round piceous spot. Elytra yellowish hyaline with a brównish vitta following the median nervure of the corium to the transverse nervures where it is deflected inwardly; the marginal and apical nervures, the claval commissure and two vittæ on the disk of the clavus brown.

Form broad with a wide head and short vertex, the latter with distinct fovæ; front moderately broad almost parallel, carinæ distinct, apex straight; basal joint of the antennæ almost as long as the second. Pronotum about as long as the vertex, truncate behind, the lateral carinæ divergent, almost attaining the hind edge. Scutellum moderately contracted at apex, sides regularly arcuated, lateral carinæ a little devergent at apex. Length 3½ mm.

Brachypterous female: Scutellum shorter with the lateral carinæ as usual more divergent and the sides nearly rectilinear. Elytra scarcely attaining the second tergal segment, dark brown with pale margins and nervures. The pronotum and scutellum are piceous brown with three pale vittæ following the carinæ.

Described from one macropterous female taken from grass in a damp place by the Railroad tracks just west of the station at Kingston, and a brachypterous female from Mandeville. The broad form and straight lateral carinæ of the pronotum as well as the general pattern of marking separate this species from *Liburnia* but I can find no established genus in which it can be better placed and do not care to found a new genus without access to fuller material.

Liburnia ? dorsilinea n. sp.

Size and general aspect of *Stenocranus dorsalis* but with a broad and short vertex. Dull testaceous brown with a whitish dorsal stripe on the vertex, pronotum and scutellum which is continued slenderly along the elytral commissure to the tip of the clavus; elytra with a brown longitudinal vitta, obsolete toward the base but strongly accentuated beyond the transverse nervures; the surface interior to this vitta darker especially toward the apex, with the nervures fuscous. Wings smoky hyaline with fuscous nervures. Clypeus, legs and lower surface pale becoming whitish on the sides of the venter; oviduct black on either side.

Head broad with a short vertex, the fovæ poorly defined. Front moderately broad, rectilinear, scarcely narrowed between the eyes; apex very feebly emarginate, median carina not strongly distinguished. Pronotum short, posterior margin quite deeply emarginate, lateral carinæ following the curve of the eyes. Scutellum large with the sides regularly arcuated. Length to tip of the elytra 5 mm.

Described from one macropterous female taken at Balaclava April 5th. In color and marking this large species bears a striking resemblance to our northern *Stenocranus dorsalis* but it can at once be distinguished by the short and broad vertex, broad concolorous front, and the curved lateral carinæ of the pronotum. The carinæ are poorly defined.

Family Cercopidæ

Tomaspis bicincta Say.

One example was swept from rank vegetation on a stony hillside at Mandeville, March 31st. In this individual the transverse bands are very faintly visible. It does not differ otherwise from specimens of var. *ignipecta* in my collection from the United States and Mexico.

Clastoptera funesta Stal ?

With the preceding I took one example of a small *Clastoptera* related to *proteus* that I place with some doubt as Stal's *funesta*. It is deep black with a yellow band across the apex of the front, another on the pronotum, and the base of the scutellum is also yellow. The elytra have a large square black spot on the middle of the costa about which is an arc of reddish salmon color fading to hyaline at apex and along the costa, and to black at base and on the clavus. At the apex of the costa is the usual black dot. Legs whitish dotted and banded with black on the tibiæ and tarsi.

Family Membracidæ

Of this family I took what I believe should be listed as ten species. Five of these I have been able to place with some degree of certainty, the others I have been unable to locate satisfactorily in their proper genera. Some and possibly all these doubtful forms are probably still undescribed but my acquaintance with this family and the material at my disposal is much too limited for me to attempt to describe new forms, nor do I know of a student of the family to whom I could look for assistance. I have therefore contented myself with placing these doubtful species as nearly as I could in their proper sequence leaving their identification for some future time.

Subfamily Smiliinæ

Acutalis calva Say?

Three specimens of what I believe to be this species were taken at Hope Gardens, March 27th, one at Mandeville, April 3d, and one at Balaclava. These are a little smaller than the same species as found in the United States but I cannot see that they differ in any other respect.

Micrutalis malleifera Fowler.

One example taken at Hope Gardens, near Kingston, with the preceding. This individual agrees with Fowler's description in every respect. It is but little more than half the size of the *Acutalis* mentioned above but I can see no possible reason for placing it in a separate genus. In this specimen the pedicellate apical areole is reduced to a mere point but is still quite distinguishable.

Three other species of this subfamily were taken by me that I have been unable to assign to their proper genera. One of these, of which I took a good series, superficially resembles *Trachytalis isabellina* Fowler, figured in the Biologia, Homop.

ii, pl. 7, fig. 25. In the female of this species the elytra are narrowed to an acute apex much as in *Polyglypta*.

Subfamily Darninæ

I took quite a series of what I believe to be varieties of one species belonging to this subfamily. Of the 23 specimens taken hardly two are alike. They vary in size as well as pattern of marking, but all are small.

Subfamily Centrotinæ

Callicentrus aurifascia Walker. (Cat. of Homop. p. 618.)

At Montego Bay I took one female that I believe should be placed here. This specimen has nearly the whole front of the thorax bright yellow, and wants the "stripe of pale yellow down each side of the breast" and the "bright yellow stripe each side beneath the abdomen". It also differs in the color of the tibiæ and in the presence of the band of white tomentum on the sides of the pleural pieces. *Pyramba aurifacies* (n. gen. et sp) Buckton (Monograph p. 248.) is a closely allied species, but apparently wants the white spot on the base of the corium and has the posterior process of the pronotum extended to the apex of the closed elytra. Buckton's genus *Pyramba* is certainly identical with *Callicentrus* Stal but it would not be valid in any case as he gives no indication of the characters on which he purports to found it. Buckton's Monograph is almost worthless for determination; his figures are unrecognizable and the descriptions, so far as I have had occasion to make use of them, are no better, while his nomenclature in places is positively weird. It would be a boon to all students of this group if some entomologist who understands the characters of the Membracidæ would go over Buckton's types while they are still accessible and tell us what they really are.

Callicentrus jucundus Walker. (Cat. of Homop. p. 620.)

I took one male at Montego Bay that agrees in every essential particular with Walker's description. Another male taken at Balaclava, April 4th, differs in being a little larger, of a uniform ferruginous brown color on the head and prothorax and in having a longer and more protracted head with its apex more rounded. The legs also are paler in color and the humeral angles are more rounded and prominent. It does not agree with any of Walker's other Jamaican species of Centrotus and is probably undescribed.

Stal founded this genus for *Centrotus ignipes* Walker and *flavivitta* Walker. After a careful study of the descriptions and material accessible to me I would place the following species in this genus, all from Jamaica:

Suprahumeral horns broad:
  - C. *ignipes* Walker. Cat. Homop., p. 616.
  - C. *platycerus* Walker. Cat. Homop. p. 618.
  - C. *cribratus* Walker. Cat. Homop. p. 619.

Suprahumeral horns slender, acute:
  - Prothorax marked with yellow vittæ:
    - C. *flavivitta* Walker. Cat. Homop. p. 617.
    - C. *aurifascia* Walker. Cat. Homop. p. 618.
    - C. *aurifacies* Buckton. Monog. p. 248.
  - Prothorax without the yellow vittæ:
    - C. *jucundus* Walker. Cat. Homop. p. 620.

Aethalion nervoso-punctatus Sign.?

While at Mandeville I took two examples of a small *Aethalion* that is very near Signoret's species. A comparison with Mexican material may, however, show it to be distinct.

In placing this genus under the Membracidæ I do not wish to be understood as passing any judgment as to its systematic position. Perhaps a more logical arrangement would be to place it as a separate family of equal rank with the Membracidæ on the one hand and the Bythoscopidæ on the other, and arrange these with the Tettigonidæ and Jassidæ in the super-family Jassoidea.

Note: I took at Mandeville four examples of a very small brown insect belonging to the Centrotinæ that I have been unable to locate in any described genus. It is a roughly punctured little fellow, two millimetres in length, with the basal one half of the elytra coriaceous and punctured. The pronotum is triangularly produced to about the middle of the abdomen and wide enough to cover most of the scutellum.

Family Bythoscopidæ

Agallia novella *var.* **tropicalis** n. var.

While on the island I took a long series of what I prefer at present to place as a variety of this species. They were most abundant at Mandeville but I took them also at Balaclava, St. Margaret's Bay, Hope Bay, Richmond and Kingston. These are all smaller than the species as found in the United States, (2½ to 3 mm.), the clypeus is narrower toward the apex, and the sinus of the last ventral segment of the female is much more shallow with the outer apical angles more produced, forming a prominent blunt tooth. The colors vary as widely as in our northern form but the dark males differ from the northern males in having the disk of the pronotum before the middle marked with a more or less extended pale spot bisected by a rather broad black longitudinal line. In *novella* from the United States there is a narrow black median line bordered either side by pale which may be so extended as to cover nearly the whole surface. In the dark Jamaican males the elytra are almost black with a costal area, broadest at the middle, the claval suture, an oval spot at its base, an elongated angular mark on the claval commissure near its apex and the claval surface within the inner nervure, pale yellow, or subhyaline on the costal area. In even the palest females the rounded apex of the clypeus, the lateral sutures of the front and clypeus, the antennal pits, two dots on the vertex, two on the disk of the pronotum, and the basal angles of the scutellum are black; the frontal arcs, the sutures of its base with an abbreviated median line from its angle, a spot on the ocelli, the median line on the pronotum anteriorly and a cloud on its anterior margins behind the eye are ferruginous, and in darker examples become black. In the paler examples the elytra are yellowish hyaline, faintly smoky at apex, with pale nervures, between which are indications of fuscous lines.

The study of material from intermediate localities may make it advisable to raise this form to specific rank but its present assignment will serve to show its affinity with *novella*.

Agallia lingula n. sp.

Allied to *novella* but with the vertex perhaps a little more angulated and the pronotum shorter. Front a little broader than in *novella* with the sides more strongly arcuated, the basal sutures meeting in a more obtuse angle, and wanting the short median line running from the apex of the angle toward the hind edge of the vertex; clypeus a little shorter and more ovate and the lore broader than in the Jamaican form of *novella*. Last ventral segment of the female short, truncated, with a slender ligulate process, fully as long as the basal portion of the segment; plates more slender than in *novella*, their sides parallel and apices acute. Length scant 3 mm.

Color pale brownish testaceous becoming more yellowish on the head apex of the scutellum and legs; vertex with a round black dot over each ocellus; the latter placed on a brown dot; sutures of the face, apex of the clypeus, pleural pieces, some marks on the base of the vertex and the disk of the tergum, black. Front, except the middle line, some obscure marks on the apex of the vertex, a lobate oblique spot either side of the anterior margin of the pronotum, and the base of the scutellum ferruginous brown; from either lateral angle of the pronotum an indefinite pale ray follows the anterior margin and invades the lobate brown mark; disk of the pronotum discolored posteriorly, the pale color forming a triangular spot with its apex resting on the base of the vertex. Elytra brown, almost unicolorous, a little darker along the commissural margin and apex, nervures pale; nervures of the wings fuscous.

Described from one male and two female examples taken at Montego Bay, April 7th. This species may be distinguished from *novella* by its wanting the black dots on the pronotum and scutellum, and by its having those of the vertex a little farther apart; the pale color of the pronotum also is differently arranged forming a triangular mark on the disk anteriorly in place of a pale area either side of a median dark line. The form of the last ventral segment of the female is also quite distinctive.

Agallia basiflava n. sp.

Allied to *sanguinolenta.* Front broader and shorter than in *novella* with the sides more deeply sinuated below the eye; clypeus narrower and more nearly linear. Last ventral segment of the female long, obtusely triangular, the apex truncated or slightly emarginate. Valve of the male longer than in the preceding two species, plates broad and short, forming an obtuse triangle with its sides feebly sinuated and its apex rounded. Length 3 mm.

Color pale ferruginous brown; face with two dots placed on the ocelli, two others above these on the vertex, antennal pits, and sutures of the front, black; cheeks broadly whitish, subhyaline; orbits of the eyes, a large quadrate median spot on the vertex, excepting the median line and including the four black points, a bilobate median vitta on the front and the sides of the clypeus basally, pale cream white. On the pronotum is a pale border to the dark median line meeting in front and produced either side in a curved winglike mark that does not quite attain the latero-posterior angle. Scutellum with a black spot within the basal angles and three approximate pale spots on the apical field, the larger of which occupies the apex. Elytra pale brown clouded with darker, especially at apex and in an indefinite oblique vitta before the middle; anterior to this oblique vitta the nervures are broadly yellow, behind they are mostly pale with a few brown interruptions. In pale examples the oblique vitta is indicated by a sagitate blackish mark before the apex of the clavus. Pleural pieces and base of the abdomen blackish; produced tip of the ultimate ventral segment of the female brownish. Legs pale, the posterior tibiæ dusky beneath.

Described from one pair taken at Balaclava, April 5th, another example taken with these, and two others from St. Margaret's Bay, April 12th. This species may best be distinguished from *novella tropicalis* by its wanting the black dots and median line on the pronotum and the black apex of the clypeus. The yellow veins on the base of the elytra seem to persist. The genital characters are very characteristic and in the female seem to ally this species with *tenella* O. & B. from Mexico.

Agallia liturata n. sp.

Form of *constricta* nearly. Front broad, strongly sinuate below the antennæ, apex broad, abruptly narrowed to the clypeus which is somewhat ovate. Last ventral segment of the female short at the sides, the outer angles a little prominent, the middle one third produced and almost square with the apex broadly angularly emarginate. Valve of the male transverse, appearing as an additional ventral segment; plates together triangular, a little longer than broad at base, sides slightly sinuated, apex obtuse. Length 3 to 3½ mm.

Color pale fulvous brown, vertex except the median line and another near the eye, cheeks, loræ, and the usual bilobate median vitta of the front, pale; frontal sutures, apex of the clypeus usually, antennal pits, ocelli, and two dots above them on the vertex black. Pronotum with pale marks forming two arcs beginning at the middle of the anterior margin and diverging to the center of the disk where they are deflected at right angles almost to the inner angle of the eye, behind which they form an oval ring. In dark examples the median vitta, a small spot at the inner angle of the eye and a larger oval one near the basal margin either side of the eye are deepened almost or quite to a black color. Ground color of the elytra brown on which the strong nervures are conspicuous, these are connected by a number of supernumerary transverse nervures in the marginal and apical areoles and on the clavus. Wings deep smoky brown with blackish nervures. Scutellum pale with the basal angles and a median spot dusky. Abdomen pale with the tergum darker and the apex of the ultimate ventral segment dusky. Legs pale, the posterior tibiæ embrowned beneath; tarsal claws deep black.

Described from fifteen examples taken at Rock Fort, near Kingston, March 25th; Montego Bay, April 7th; Richmond, April 15th and Mandeville. This species must bear a very close resemblance to *Balli* Baker (described as *reticulata* by Ball; Psyche, IX, p. 127, 1900) from Hayti but the very different genital characters will at once separate them.

Agallia scortea n. sp.

Form of *oculata* nearly, Vertex very short; face flat; front short and broad, sides feebly sinuated below the eye and rounded to the broad apex; clypeus long, widened apically; loræ rather wide, cheeks strongly angled at about their middle, not attaining the apex of the loræ. Pronotum unusually

long, the latero-posterior margins much extended, posterior margins feebly sinuated, almost entirely covering the basal field of the scutellum. Elytral nervures inconspicuous, ultimate ventral segment of the female but little longer than the penultimate, apex truncated, almost parallel with the basal. Valve of the male inconspicuous, broad triangular, its apex truncated, plates hardly twice the length of the valve, much shorter than the pygofers which together with the plates form a long triangular segment. Length 3 to 3½ mm.

Color a soft fulvous brown. Head pale yellow; two small dots on the vertex placed close to the basal margin and wide apart, a larger angular spot close to the inner angle of the eye, a minute dot below this placed near to the inner margin of the eye, the ocelli and antennal pits, black; on the apex of the vertex is a slightly discolored patch on which may be a basal brown dash or point. Pronotum a little paler about the borders; two small distinct black dots placed well forward on the disk and two minute points close to the anterior margin either side of a slender short median dash, dark brown or black. Scutellum yellowish with the minute acute tip deep black; the incised transverse line brown. Elytra pale, subhyaline, highly polished, the nervures inconspicuous and a little paler; across the middle of the elytra a darker band is indicated mostly by a fuscous cloud near the commissural margin of the clavus. Abdomen dusky beneath; disk of the tergum black. Pleural pieces deep black, edged with pale; feet pale, claws black.

Described from one male and three female examples taken at Mandeville, March 29th, and Montego Bay, April 8th. This very distinct form cannot be confused with any described species known to me. A larger but closely allied species recently taken near Buffalo, N. Y., seems to be still undescribed.

Note:—Agallia repleta n. sp.

Male: General appearance of *4-punctata* Prov. but smaller and more slender. Clear brownish testaceous tinged with fulvous on the face and with yellow on the scutellum. Front rather strongly constricted below the eye; clypeus and a large spot in the antennal cavities deep black; frontal sutures, an angled line bounding its base, an elongated curved line on each side of the front, a dot on each ocellus and a larger round spot above them on the vertex black. Pronotum with five black spots on the disk, one median and four forming a quadrangle of which the anterior are nearer, and on the anterior border is a black line behind each eye. Scutellum with a triangular spot well within the basal angles connected by another on the incised line. Elytra fuscous hyaline with the nervures pale, simple. Beneath black with the connexivum and genital pieces testaceous. Legs fulvo-testaceous. Valve very large, cut square across the broad apex, plates small, triangular, subacute. Length 2½ mm.

The female differs from the male in having the black marks on the face more extended and in having those of the pronotum represented by a curved black line, concave anteriorly, touching the anterior margin at either end, and faint indications of the median and two posterior discal spots. Elytra

Pediopsis elegans n. sp.

Closely allied to *virescens* in form but a little smaller; front broader and shorter, as in *viridis*, but with its sides straighter and apex broader; vertex longer, not as thin and sharply angled as in *virescens;* Pronotum minutely and almost transversely striate; face punctured rather than striate. Ultimate ventral segment of the female long, cylindrical, distinctly carinate along the median line; the middle of the hind edge on either side drawn out into a slender subacute appendage resembling the "tails" on some Papilios. Valve of the male very small but obvious, plates long, convex, triangular, their sides nearly straight, scarcely sinuated toward their smooth acute apex. Length, male 3¼ mm; female 4 mm.

Color in fully developed examples clear bright grass green with red markings on the pronotum. Face clear light yellow above fading to greenish toward the mouth, superior surface of the vertex and pronotum deeper green, the latter with the anterior margins and median line posteriorly clear blood red, the hind edge narrowly pale reddish; scutellum tinged with yellow on the basal angles and apex. Elytra somewhat smoky, the costa and commissural nervures green. Connexivum light yellow.

Described from nine examples, representing both sexes, taken at Mandeville, March 29th to April 3d. These were beaten from bushes the names of which I did not learn. When fully colored this is a most beautiful little insect. In immature examples the red color is barely indicated by paler marks. The males are smaller with darker elytra than the females. The form of the ultimate ventral segment of the female is very distinct from anything I have before seen in this genus.

Family Tettigonidæ

Tettigonia histrio Fabr.

This seemed to be a common species at some localities. I took it in numbers in a dry ravine at Montego Bay and in smaller numbers at Kingston. Some of these individuals are suffused with red as indicated by Stal in his description in the

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rather deeper colored with the pale nervures heavier and more conspicuous. Last ventral segment short, cut almost square off behind, but little longer at the middle than at the sides; pygofers rather thick toward their apex, unarmed.

Described from one pair taken on the island of Trinidad by Mr. Chipman. This genus appears to be well represented in the tropics. Messers Uhler, Osborn, Ball and Baker have described quite a large number from Mexico and the West Indies and five more are here added, all of which seem to be sufficiently distinct.

Hemip. Fabriciana. In many however this color is scarcely indicated and in others it is confined to one or more elytral areoles. In two examples from St. Margaret's Bay the black lines are much reduced making them very close to *T. fausta* Walker, from St. Domingo.

Tettigonia histrio var. sanguinipes n. var.

Color deep black. Head pale with two broad black vittæ that extend over the vertex and meet at the apex of the front where they form a single median vitta on the clypeus; cheeks with a black vitta below the antennæ and a broken one below the eye. Pronotum black with three longitudinal bands and the lateral margins pale. Scutellum black with a median basal spot and the broad apex pale. Elytra black; corium marked with four pale spots forming incomplete transverse vittæ; the apex smoky hyaline; clavus with four pale spots, the two apical elongated, near the commissure. Wings almost black, highly iridescent. Breast, abdomen and legs sanguineous marked with black on the pleural pieces and disk of the abdominal segments, apex of the tibiæ and tarsi and frequently the middle of the femora black or fuscous. In some specimens the pale markings are deeply suffused with sanguineous, the face may be almost entirely pale and the other pale markings may be so extended as to show clearly its relationship with *histrio*. Through the varieties figured on plate 15, figures 28 and 29 of the Biologia there seems to be a direct connection between *histrio* Fabr. and *Stalii* Sign. The present variety appears to be an extreme form even more distinct than *Stalii*, but the genital characters are the same and I cannot feel justified in describing it as a new species. Length 7 mm.

This variety was common especially in the more elevated and moist localities. It was abundant at Mandeville and I took it at Balaclava, Appleton, Richmond, Hope Bay and St. Margaret's Bay. I did not find it either at Kingston or Montego Bay.

Tettigonia macrocephala n. sp.

Somewhat allied to *gothica* but with a smaller and much more slender body. Head large, much broader than the pronotum, more rounded before than in *gothica;* clypeus more convex. Pronotum narrower, about one third longer than the vertex, almost semi-circular before, feebly concave behind, valve of the male large, rounded behind; plates narrow, subacute at apex.

Color pale yellow tinged with fulvous on the sides of the vertex and with testaceous on the pronotum. Vertex with a broad pale median vitta, angularly expanded before the ocelli, bordered by a brown line; behind the ocelli is a short brown line and exterior to them a brown cloud, temples with a blackish spot on the line between the face and vertex, apex of the head with a round black spot either side of which the frontal striæ are marked with brown where they encroach upon the vertex. Face pale with a short longitudinal brown vitta on the apex of the front and extending over on to the base of the clypeus; cheeks with a brown cloud beneath the eyes. Pro-

notum clouded in places and marked with two broken longitudinal lines continuing those on the vertex, a short curved line behind the inner angle of the eye and the latero-posterior margins dark brown. Scutellum pale with the basal angles and a transverse line faintly brown. Elytra dull sanguineous, the apex subhyaline clouded with fuscous; costa greenish yellow toward the base, nervures dark. Wings deep smoky hyaline. Abdomen yellow beneath, connexivum sanguineous, breast and legs pale yellow, mesosternum with a blackish cloud; tibiæ dotted with brown. Length 4½ mm.

Described from five examples taken at Montego Bay, April 8th. This species seems somewhat closely allied to *compta* and *tunicata* Fowler, figured on plate 18 of the Biologia, but it is smaller, has a broader and more rounded head and the markings on the vertex and pronotum are quite different.

Tettigonia similis Walker.

This pretty little green insect was common everywhere on the island. I took it at Kingston, Mandeville, Balaclava, Montego Bay and St. Margaret's Bay. As pointed out by me in Ent. News (v. p. 155, 1894) Signoret wrongly identified this species with *Helochara communis* Fitch in which error he was followed by Walker in 1858.

Tettigonia fuscolineella Fowler.

Another common species which I took at many places on the island. Prof. E. D. Ball in a letter to me considers this as a mere variety of *bifida* Say, in which he is probably correct. It has however, a shorter head and the markings, which seem to be constant, are somewhat different on the head and pronotum, and in a faunal list it can do no harm to place it under a distinctive name. Canon Fowler's material was from Mexico.

Dræculacephala sagittifera Uhler.

I found this tiny species not uncommon about Kingston and took it also at Montego Bay and Hope Bay. This is the smallest Tettigonid known to me. Some of the smaller males measure but 3 mm. to the tip of the closed elytra.

Xerophlœa viridis Fabr.

Not uncommon about Kingston and taken also at Richmond, Mandeville and Montego Bay. Most of these specimens were of a clear light bluish-green color but a few were washed with brown on the pronotum, scutellum and elytral commissure. I believe Osborn and Ball were quite right in placing ***grisea***

Germ , *virescens* Stal, and *peltata* Uhler as synonyms of this species. *X. viridis* and *peltata*, the two forms I have examined, while variable seem to exhibit no differences of specific value.

Gypona unicolor Stal.

Prof. Ball doubtfully determines this as *unicolor* and I can see no good reason for changing it. The hind margin of the last ventral segment of the female is rather broadly and deeply excavated, a character that would ally it with *Germari* Stal.

I took this species at Kingston, Balaclava, Montego Bay and St. Margaret's Bay. It was taken singly on bushes.

Gypona nupera n. sp.

Female : Most nearly allied to *Wallengreni* Stal and *nana* Fowler. Above dark testaceous brown inclining to olivaceous; beneath pale yellow. Head short, about as wide as the pronotum. Vertex of about equal length across its whole width, incised median line and a dot on the hind margins almost behind each ocellus black; ocelli sanguineous, placed before the middle of the vertex and about equally distant from one another and from the eyes; anterior edge of the head well rounded to the front, transversely striated or furrowed, the striæ straight, simple. Front broad and short, strongly and convexly narrowed to the apex, base feebly but distinctly transversely depressed. Clypeus rectangular, about one third longer than broad; cheeks broad, slightly tinged with green. Pronotum about two and a half times the length of the vertex, strongly transversely striate; anterior margin paler marked with a pair of approximate black dots at the middle and a curved brown line and a few points on either side; lateral margin narrowly yellow, bordered within with fuscous. Scutellum with the curved incised line fuscous. Elytra rather short, nervures pale dotted with fuscous, basal one fourth of the costa pale yellow, bordered within by a fuscous line which beyond runs along the costal margin, where it is dotted with pale, to the apical third and is expanded inwardly over the apex of the costal areole; beyond this brown cloud is a clear spot followed by a fuscous one on the tip of the first apical areole; elytral appendix and two or three commissural marks brown. Wings almost black. Tergum ferruginous, the incisures slenderly pale. Legs whitish, the tarsal spines and claws brown. Last ventral segment a little longer than the preceding, the apical margin broadly concavely arcuated with a median notch barely indicated. Length 7 mm.

Described from one female taken at Mandeville, April 3d. I cannot identify this species with any description known to me. The short vertex, testaceous brown color, with dotted nervures and costa, the latter marked with a yellow base and spot toward the apex, and the yellow and fuscous lines on the sides of the pronotum and base of the costa will most readily distinguish it.

Family Jassidæ

Spangbergiella vulnerata Uhler.

I took about eight examples of this pretty species at Mandeville, Kingston and Richmond. These have the red dorsal lines quite widely dislocated where they pass from the pronotum to the vertex. From the descriptions and figures I have seen of this species I gather that usually these lines are nearly continuous and not so closely approximated anteriorly.

Xestocephalus pulicarius Van Duzee.

I took at Montego Bay one rather large clearly marked female that certainly belongs to this species. It was swept from the short grass growing along the roadside just east of the village. This individual has a large quadrate dark spot on the costa beyond the middle and a narrower one nearer the base. The form of the last ventral segment differs in no wise from that found in material taken in the United States.

Xestocephalus brunneus n. sp.

Female: Color a rich soft brown becoming paler on the head and legs; abdomen piceous with the pygofers paler at base. Vertex short and more rounded than in *pulicarius*, with the front immaculate except for a small pale dot above the ocelli. Pronotum short, distinctly transversely striate, a little paler behind the eyes, otherwise immaculate. Scutellum slightly paler on the disk, the transverse incised line dark. Elytra paler beyond the middle, scarcely maculated at base, the discal transverse nervures of the corium and a dot at the tip of each claval nervure obsoletely paler; a quadrate spot on the middle of the costa, a smaller and darker one beyond this, and the broad apex darker, the sutural margin with two pale spots beyond the clavus and there is another opposite to these on either side of the costal spot. By transmitted light the disk of the corium shows faint indications of some of the paler spots found in *pulicarius*. Wings smoky hyaline, iridescent. Ultimate ventral segment short, anterior and posterior margins parallel, leaving the apex subangularly concave, the median notch found in the allied species scarcely indicated; pygofers proportionately shorter and broader than in the allied species. Length about 2 mm.

Described from a female example taken in a small dry gully at Montego Bay, April 7th, and another female taken at Kingston, R. I., and kindly sent me by Prof. John Barlow of the Agricultural College located there. The specimen from Rhode Island is a little larger and darker but seems to differ in no other way from that taken in Jamaica. The four previously described species in this genus show but slight variations in the form of the last ventral segment of the female and the present species is no exception. I believe however that *brunneus* is a good species that may be distinguished by its uniform rich brown color, with the elytral maculation almost obsolete except at apex.

Xestocephalus ornatus n. sp.

Male: A little smaller than *pulicarius* with the vertex more produced. Clear light lemon yellow. Eyes, a small oval spot on the anterior margin of the pronotum, a transverse band on the base of the scutellum continued across the base of the clavus, a common large quadrangular spot on the middle of the elytral commissure, bisinuated exteriorly and including a central oval spot of the ground color, and three points on the costa opposite to this quadrangular spot, black. Corium less deeply colored and becoming a little smoky toward the apex, and almost white exterior to the black discal mark. Antennæ, legs, and lower surface of the body whitish.

Vertex produced, obtusely rounded at apex, its length three fourths its width at base. Pronotum one fourth longer than the vertex, hind edge rather deeply arcuated, lateral and latero-posterior margins subequal, rectilinear, meeting at a right angle. Valve large, roundedly truncate at apex; pygofers one half longer than the valve, subacutely triangular, sides almost rectilinear, surface armed with coarse white bristles.

Female a little larger. Common commissural black mark reduced to two curved vittæ, connected posteriorly, and including the broad oval discal spot which connects anteriorly with the ground color. Last ventral segment longer than the preceding, apical margin broadly, angularly excavated so as to be nearly parallel with the basal. Pygofers strongly narrowed toward their apex and sparcely armed with white bristles. Length 2½ mm.

Described from two male and two female examples taken at Mandeville. This very pretty little species introduces a new facies in this genus, so far as it is known to me at least.

Xestocephalus bipunctatus n. sp.

A little larger than the preceding. Soiled white tinged with yellow on the scutellum and faintly clouded with smoky toward the apex of the elytra. These latter marked with a conspicuous black dot at about the middle of the commissural margin, a minute brown point anterior and exterior to this, about three blackish dots on the costa, and an obscure one on the inner margin just beyond the apex of the clavus which extends along the transverse nervure for a little space. Face and lower surface tinged with ferruginous; legs whitish with dark tibial spines, the femora lineated with brown. Vertex obtusely conical, its length two thirds its width at base. Pronotum about as in *ornatus*. Last ventral segment of the female and the pygofers shaped about as in *ornatus*, but the former more deeply excavated. Pygofers of the male small, obtusely triangular, armed with stout white bristles. The position of this male as mounted is such that I cannot make out satisfactorily the form of the valve and plates. Length 2½ to 3 mm.

Described from one pair taken at Mandeville. This is a little white insect with much the aspect of a diminutive white *Phlepsius*.

Xestocephalus Balli n. sp.

Aspect of a small *Eutettix seminuda.* White, tinged with fulvous on the vertex, pronotum and scutellum. Front suffused with ferruginous and sending two slightly divergent lines of the same tint over the apex of the head to about the middle of the vertex where they are deflected and end in two brown dashes, anterior edge with a black point close to each eye. Anterior border of the pronotum with a few brown marks and a black point behind each eye, disk with an angulated transverse pale brownish vitta produced anteriorly on the middle and deflected laterally almost to the posterior angles, disk posteriorly with a vague median cloud. Scutellum a little darker toward the base. Elytra white, becoming a little smoky toward its apex; marked before the middle with a strong oblique angulated fuscous vitta widened into a large square blotch on the middle of the claval commissure; behind this on the costa is a small dot at the middle, a larger one on the node and another at the first apical nervure; inner margin with a short oblique fuscous vitta just beyond the apex of the clavus, and the transverse nervures beyond the middle are touched here and there with brown. Legs white; the tibiæ and tarsi spotted with fuscous. Length 3¼ mm.

Described from one female example taken at Mandeville April 3d.

Platymetopius loricatus Van Duzee.

Seven examples of a species that I place here with some misgivings were taken by me at Kingston, Mandeville and Montego Bay. Some of these have the face entirely pale yellow, while in others it is quite evenly covered with obscure irrorations, sometimes almost indiscernable, but wherever there is any darker color on the face the pale angulated mark on the base of the front is visible. The females have the last ventral segment about as long as the two preceding united and quite strongly, almost angularly, produced at the middle. The valve of the male is short and broad and rounded behind and the plates are short and arcuated, forming a border to the valve, with a small acute apical prolongation.

Prof. Ball has kindly sent me for examination an insect from the Island of Trinidad that I believe belongs to this species.

Platymetopius nasutus n. sp.

Form and general appearance of *loricatus*. Vertex strongly produced, its length about twice its width between the eyes at base, surface flat and horizontal. Front a little wider toward the apex than in *loricatus*, the sides of the clypeus a little less arcuated and the cheeks broader and more rounded outwardly. Pronotum unusually short, the hind margins feebly concave. Last ventral segment of the male short, a little angularly excavated behind; valve large, ovately triangular, the apex obtusely angled, plates a little longer than the valve, broad, sides nearly straight, slightly rounded to the blunt apices, edges fringed with long bristles; pygofers considerably exceeding the plates, obtuse at apex. Last ventral segment of the female short, broadly triangular, at apex obtuse; pygofers stout, scarcely exceeded by the oviduct.

Color dark fuscous brown, vertex becoming almost black toward the apex, marked before the eyes with a rather broad transverse white band that is slightly angled and is crossed by from three to five longitudinal dark lines; slender edge of the vertex and a spot at the tip white. Front pale or clouded with fuscous with a white mark at base. In the female from Jamaica the face is clear yellow clouded with fuscous on the cheeks exteriorly, within which are some sanguineous irrorations. Pronotum and scutellum irrorated with pale, the former with four pale longitudinal lines indicated, the latter with the extreme tip and two marginal spots on each side pale. Elytra white, nervures fuscous, areoles rather strongly reticulated and in part irrorated with brown, the oblique costal nervures nine to twelve, strong. In the male the elytra are darker showing the usual white spots quite strongly; the inner apical areole with a white lunule bordered with brown, which forms an annulus when the elytra are closed and is most conspicuous in the female. Wings suffused, with fuscous nervures. Length 4 mm.

Described from one pair: a male from Durango, Colorado, received from Prof. Ball, and a female taken by me at Mandeville. In most of its characters this species is close to *frontalis*. The longer and more clearly marked vertex and the generally paler colors may not be characters of specific value. The genitalia, while of the same general pattern show differences that it seems to me entitle this to specific distinction. The plates of the male are longer and more rounded toward the apex and the last ventral segment of the female is shorter and more triangular.

Platymetopius nanus n. sp.

General appearance of *frontalis* but much smaller. Dark chocolate brown above; entire face pale yellow. Vertex a little more acute at apex than in *frontalis* but similarly marked with an abbreviated longitudinal pale dash at apex, two approximate parallel ones between this and the eye, and a pair of smaller ones at base placed on either side of the dark median line; clypeus distinctly longer than in *frontalis*, considerably surpassing the cheeks, quite strongly constricted toward its base; loræ narrow, outer edges of the cheeks rectilinear. Pronotum almost truncated before between the eyes, very minutely and obscurely irrorated with paler, and showing five indistinct longitudinal lines of pale points. Scutellum with the basal angles blackish and carrying a pale point at the extreme tip of the angles, and another at each basal angle of the apical field. Elytra with the vermiculations and nervures but little darker than the surrounding surface, white points scarcely obvious except three pairs along the claval commissure of which the basal are very minute; costal area hyaline, broadest posteriorly, and crossed by eleven or twelve oblique nervures, of which four or five are placed close together near the stigmatal region. Propleura yellowish white, polished like the face, with a brown cloud anteriorly and a black spot on the sternum; remainder of the lower surface grey varied with brown. Legs pale yellow; tip of the rostrum and tarsal claws black. Last ventral segment of the female pale at base strongly produced and truncated at apex; pygofers but slightly exceeded by the darker oviduct. Valve of the male very large, semioval, convex, the rounded apex pale; plates pale, narrow, strongly sinuated on the sides, the short slender apicies and edges fringed with pale bristles. Length, male 3 mm; female 3½ mm.

Described from one female taken at Appleton, April 10th, one male from Montego Bay, and one male taken along the railroad track just west of the Kingston station, April 17th. This is the smallest *Platymetopius* known to me. It may be recognized by its close resemblance to *frontalis*, but the entire face and most of the propleura is pale yellow and the form of the male genitalia is very distinct.

Platymetopius brevis n. sp.

Most nearly related to *fuscifrons* but smaller with a still shorter vertex. Color above greyish testaceous much as in *cinereus* O. & B. Vertex short, triangular before, scarcely more produced than in certain species of *Deltocephalus*; quite strongly tinged with fulvous; median furrow generally a little darker, disk marked either side by an oval pale spot opposite the anterior angle of the eye and a dart at base, another pale line follows the inner margin of the eye a little way from its base; extreme edge of the head with five ivory white spots which show above as a median spot and a ring about each ocellus. Pronotum very short at the sides showing five distinct longitudinal pale lines. Scutellum tinged with fulvous, the incised line black; basal angles of the apical field pale. Elytra with the nervures and reticulations strong, brown; the areoles with some white spots and mostly bordered with minute pale points; costal field broad with from eight to twelve strong oblique nervures. Wings highly iridescent. Face pale yellow, closely covered with fuscous irrorations which omit a slender median line and some short arcs on the front and most of the clypeus and loræ; base of the front with a white point, sutures black; disk of the cheeks with a small blackish cloud; clypeus not exceeding the cheeks, moderately widened at apex; loræ large. Beneath brown, pleural pieces edged with pale, the propleura with an oblique pale vitta. Legs pale dotted with brown. Last ventral segment of the female short, moderately produced, with a pale discal spot on either side of the median line; oviduct scarcely longer than the pygofers, blackish on the sides. Valve of the male large, apex slightly angled and appressed, plates long, acute at apex, their sides but slightly sinuated; black, fringed with black bristles. Length 3½ mm.

Described from one male taken at Mandeville, March 30th, and three females from Kingston. This species may be distinguished by its short vertex, the five polished white dots on the anterior edge of the head, the infuscated face and the pale point on the base of the front.

Deltocephalus flavicosta Stal.

Common and widely distributed in Jamaica. All the specimens brought home were of the pale variety described by Stal from Brazil and lately redescribed by Dr. Uhler from St. Vincent as *D. retrorsus*. The darker northern form described by me in 1892 as *D. flavocostatus* is probably identical with Stal's species, as pointed out by Prof. Baker some years ago, although the male plates are narrower and the last ventral segment of the female is more produced and not sinuated as in the southern examples. In the United States this form is common throughout the southern states and is distributed west at least to Kansas and Iowa and northwardly to western New York.

Deltocephalus senilis n. sp.

Size and general appearance of *Sayi* to which it seems to be related in the form of the facial pieces, vertex and pronotum. Vertex with the anterior margin and median vitta ivory white, the former carrying six brown points, one either side of each ocellus and a fainter pair at the tip; the median vitta bisected at base by an incised brown longitudinal line. Pronotum with five longitudinal pale lines which may be more or less distinct. Scutellum paler at tip. Elytra a little narrower than in *Sayi* but of the same length and with similar venation; nervures pale, most of the areoles more or less distinctly edged with brown and a few carrying fuscous spots; most persistent of these is a rather large one on the sutural margin of the clavus a little before the middle and a somewhat fainter one on the corium exterior to and behind this. Face brown, darker above; about eight arcs on either side of the front, an indistinct median vitta, a discal spot on the clypeus either side of the median line, and the disk of the loræ and cheeks below, pale. Body and beneath brown varied with pale, the tergum in some examples almost black. Legs pale more or less distinctly banded and spotted with brown; apex of the last ventral segment of the female feebly bisinuated forming three rounded teeth, the middle a little the larger. Valve of the male very short; plates short, rapidly narrowed to a rather slender point. Pygofers prominent beyond the plates and armed with short bristles. Length 1½ to 2 mm.

Described from 15 examples, representing both sexes, taken about Kingston from March 25th to April 17th; and one from Richmond taken April 15th. In the paler examples the dark marginal dots on the vertex are almost obsolete but the pair adjoining the ocelli is always discernable. Generally there is a fuscous vitta on the apex of the elytra which is interrupted by the pale nervures. Prof. Ball suggests that this may prove to be an extreme variety of *flavicosta*.

Deltocephalus nigrifrons Forbes?

I took a single male example of what may prove to be a small form of this species at Rock Fort, near Kingston. This individual has the vertex distinctly longer and more angled than in my northern material of *nigrifrons*. It may represent a new species but in the present unsettled state of the synonomy of this species I prefer to leave it here with a mark of doubt.

Athysanus exitiosus Uhler.

This was a very abundant species everywhere I collected on the island especially at Richmond where I found them in great numbers on grass along the roadside. These were smaller and darker than those from the United States, the males in particular sometimes were almost black.

Eutettix Balli n. sp.

Form nearly of *Johnsoni* but smaller with a shorter vertex. Pale testaceous yellow. Two minute points on the base of the front, two larger ones on the ocelli, a pair of minute ones on the vertex between the latter, a round spot on each side of the pronotum behind the eyes, and two marginal points on either side of the scutellum, black. Elytra with a few brown marks. Front rather narrow toward the apex, clypeus, loræ and cheeks about as in *Johnsoni;* the antennal pits deep and marked by a blackish spot; vertex sloping, anterior edge rounded, scarcely longer on the middle than next the eye, hardly one half the length of the pronotum. Pronotum with a transverse spot on the disk and an angular mark anteriorly bisected by the nearly obsolete pale median line. Anterior field of the scutellum with minute brown points on the middle, the edges a little paler marked with two black points on either side. Elytra subhyaline, golden brown with coppery reflections from the highly iridescent wings beneath; clavus with a fuscous cloud at apex of each areole and a fuscous point near the base; corium with two fuscous discal spots before the middle, the anterior smaller and placed on the transverse nervure, apical areoles very slightly enfumed, the inner apical nervure a little infuscated, base of the two outer anteapical areoles with brown points. Breast and legs pale, the posterior tibiæ dotted with brown. Metanotum black. (Abdomen wanting.) Length to tip of the elytra 4 mm.

Described from a single example taken at Montego Bay, April 8th. This very distinct species may be known by its pale color, the four black points on the vertex in a transverse row, and the two conspicuous round black spots on the sides of the pronotum behind the eyes. It affords me pleasure to name this neat little species for my friend Prof. Elmer D. Ball who has very kindly assisted me in the determination of some of the doubtful forms here enumerated, and whose unfailing energy has added so much to our knowledge of the North American Homoptera.

Phlepsius cinereus Van Duzee.

I found this species in numbers on low tangled vines and herbage along the roadside a little north of the village of Richmond on April 15th.

Acinopterus acuminatus Van Duzee.

Richmond, April 15th, three examples. Two of these were swept from grass and weeds along the roadside in company with the preceding species. They seem to differ in no respect from our northern specimens.

Scaphoideus fasciatus Osborn.

I took two examples of this species at Mandeville, March 30th, and a third from near the railroad track a little west of the station at Kingston, April 17th. These agree in all respects with a pair in my collection taken by Mrs. Annie Trumbull Slosson at Biscayne Bay, Florida, and an example taken by me at Rivington, N. J. With the Rivington specimen I took what I place as the typical *sanctus* Say. Prof. Osborn has fully indicated the characters by which these closely allied species may be distinguished and I quite agree with him that for the present at least they should be considered distinct species.

Thamnotettix colonus Uhler.

Taken at Hope Gardens and near the Constant Spring Hotel at Kingston, at Mandeville, and from Richmond, where they were common in a pasture on the hillside above the town. The types were from the Island of St. Vincent. Dr. Uhler placed this species in genus *Deltocephalus* but it seems to me that its affinities are rather with *Thamnotettix* although the front is somewhat broader than in our more typical species.

Thamnotettix comata Ball.

I took numerous examples of this species at Kingston, Mandeville, Balaclava, Hope Bay, and Richmond. These differ from Ball's description in wanting most of the black markings above except the two large round spots on the vertex and two minute brown points between them on the apex of the head. I have however in my collection specimens from Washington, D. C., and Florida that were determined by Prof. Ball as his *comata* and agree with these Jamaican specimens in every particular. Like the preceding species this was described as a *Deltocephalus* but it seems to me that its affinities are with *Thamnotettix* where I prefer to place it. In form and ornamentation these specimens agree almost exactly with *colonus* Uhler, but they are much smaller and are sufficiently distinct in their genital characters. The types of *comata* were from Mexico.

Thamnotettix rubicundula n. sp.

Female: Form of *placida* Osborn, nearly, but much smaller. Pale yellowish tinged more or less strongly with sanguineous. Vertex short, a little longer on the middle than next the eye, moderately sloping, the edge well rounded to the base of the moderately broad front; clypeus narrow; cheeks feebly angled below the eye. Sides of the pronotum short with a thickened carina. Face, lower surface and tergum more deeply suffused with sanguineous than above. Legs pale tinged with red, especially the anterior pair. Tergum black on the disk. Last ventral segment with a narrow but deep and rounded sinus the mouth of which is contracted by a projecting tooth, either side of which the apical margin is feebly sinuated; pygofers stout, scarcely exceeded by the oviduct. Elytra subhyaline, nervures rather strong, pale sanguineous. Length 3½ mm.

Described from one female example taken at Rock Fort near Kingston March 25th. This species is so distinct from anything known to me that I do not hesitate to describe it from a unique specimen.

Thamnotettix fessula n. sp.

Form of *placida* Osborn but much smaller with the vertex more produced. Clypeus slightly widened at apex; cheeks broad, prominently angled below the eye, the edge beyond almost rectilinear, forming a broad margin exterior to the small loræ. Last ventral segment of the female rather short, the outer angles rounded either side of a rather broad median sinus, at the center of which is a spatulate tooth similar to that found in *clitellaria*, but shorter.

Color fulvo-testaceous, somewhat paler on the vertex, scutellum, elytral nervures and beneath; vertex with a slender median line at base and a small oval spot just above each ocellus ferruginous; the facial incisures and a series of arcs on either side of the front pale ferruginous. Eyes, claws and oviduct blackish. Length 4 mm.

Described from a single female specimen taken at Mandeville, April 3d. This species approaches *Chlorotettix* in some of its characters.

Chlorotettix viridia Van Duzee.

Taken with the following species at Richmond and about Kingston but in less abundance. Its slightly larger size, deeper green color and different form of vertex and the distinct genital characters will readily distinguish it.

Chlorotettix minima Baker. (Can. Ent. xxx, p. 220, 1898.)

Appleton, April 9th, two examples swept from rank grass along the Siloah River; Troja, April 14th, one example swept from grass by the railroad track. At Richmond I took it in numbers from a springy spot in a hillside pasture on the Alexander property and also took it at St. Margaret's Bay and Kingston. These specimens agree perfectly with Baker's description and I cannot doubt their identity. The species is very close to my *galbanata* and has almost the same form of vertex and ultimate ventral segment in the female. It is however considerably smaller and seems to be sufficiently distinct.

Chlorotettix Tethys n. sp.

Form of *lusoria* but much smaller. Vertex subangularly produced; clypeus broad, of equal width throughout, sides rectilinear, cheeks narrow, feebly angled beneath the eyes, forming a narrow margin around the ample loræ. Pronotum with a rather pronounced callous parallel to the anterior margin, the disk behind this distinctly transversely striate. Last ventral segment of the female moderately long, with the outer angles rounded and a little prominent, leaving a shallow median sinus on which rests a brownish cloud.

Color pale greenish luteous, more or less tinged with fulvous; the commissural margin at apex and some vague marks along the base of the apical areoles faintly smoky. Disk of each elytron with two small brown specks, one placed just beyond the transverse nervure near the base of the corium and a smaller one before this lying against the claval suture; elytral nervures pale; eyes, tip of the rostrum, tarsal claws and sides of the oviduct blackish. In one example the anterior submargin of the pronotum shows a sinuated darker vitta similar to that seen in certain species of *Cicadula*, and the basal angles of the scutellum may be darker. Length 4 to 4½ mm.

Described from three female examples; two taken at Kingston, April 11th, and Hope Bay April 13th, and a third taken on the Island of Martinique, July 26th, by Mr. August Busk and kindly sent to me for study by Prof. Ball.

Jassus merus n. sp.

Deep black. Vertex with the basal margin, an incomplete median line, and the carinate sides opposite the inner angles of the eyes, pale; face and deflected sides of the pronotum pale yellow, immaculate; antennal seta brown; base of the eyes pale; legs whitish, the claws and upper surface of the hind tibiæ black: sides of the pleura, a transverse vitta on the mesopleura, the edges of the connexivum and the oviduct whitish; margin of the posterior field of the scutellum in part and the slender hind edge of the pronotum, a spot on the elytral commissure just beyond the apex of the clavus and another opposite to this on the costa, the apical margin and slender costal nervure pale yellowish or soiled white.

Head distinctly narrower than the pronotum. Vertex narrow, much contracted by the approximated inner angles of the eyes where the width is about one third that at apex. Front narrow with a submarginal furrow above the antennæ: clypeus broad at apex. Pronotum short, about two thirds the length of the vertex, hind edge feebly emarginate, surface transversely rugose: basal field of the scutellum shagreened: elytra narrow, nervures strong. Length 5 mm.

Described from a single female example taken at Mandeville. This is a small slender species with a narrow head and vertex, and would fall into section "EE" of Spangberg's arrangement. The deep black of the upper surface is strongly contrasted with the pale yellow of the face and legs beneath. The pale markings on the elytra suggest the possibility of a pale vitta on the transverse nervures and more or less paling of the nervures toward the base, but allowing for such variation the species seems to be quite distinct.

Cicadula intensa n. sp.

Allied to *punctifrons* in form and pattern of marking, but smaller. Vertex flattish, sloping, very obtusely angled before, scarcely longer on the middle than next the eye. Front rather narrow: clypeus oblong, distinctly constricted toward its base. Pronotum proportionately longer than in *punctifrons*, the hind edge distinctly concavely arcuated, posterior angles prominent. Elytra as in *punctifrons*.

Color soiled white tinged with yellow on the vertex and scutellum. Front with a pair of large round black spots on its base and a few short brown arcs on either side below. Vertex with a transverse black vitta passing just behind the large brown ocelli, posterior to which is an incised median line and a pair of small discolored points. Pronotum with a sinuated dusky band behind the calloused anterior margin as is frequently the case in this genus. Scutellum with an intensely black elongated spot within the basal angles: about half of this spot is covered by the pronotum through which it may be seen. Elytra white with a brown cloud at apex: the disk of the areoles mostly fuscous, paler toward the costa. Beneath whitish with small black spots on the pleural pieces. Legs white with a few brown points. Abdomen wanting. Length 4½ mm.

Described from a single example taken at Hope Bay April 13th. This specimen is apparently a female but unfortunately its abdomen was broken off and lost in transit from the island.

The species however is so distinct that it seems safe to describe it from an imperfect example.

Cicadula sex-notata Fallen.

I took numbers of this species at Rock Fort near Kingston on March 25th. These differ in no respect from those found in the northern states except that they are smaller, measuring but 2 to 2½ mm. to the tip of the elytra.

Balclutha sp.

Rock Fort near Kingston, two examples. This genus, formerly known as *Gnathodus*, is difficult to study without more material than I have at my command. The present species seems to be most nearly related to *viridis* Osborn but differs in some respects.

Balclutha sp.

Two examples of another species I cannot determine were taken at Rock Fort. These are marked with black somewhat as in *abdominalis* but have the ocelli distant from the eyes and do not pertain to Baker's genus *Eugnathodus*.

Eualebra rubra n. sp.

White; base of the pronotum, scutellum and basal one half of the elytra orange red marked with irregular dots of purple-black. These dots are composed of minute purple points on a whitish ground which in most cases they almost entirely cover; they are arranged as follows: three small ones on the base of the vertex; three larger ones on the anterior submargin of the pronotum, the median ovate, the lateral elongated and somewhat angled and almost attaining the humeral angles; a small one on the propleura; a square median one on the base of the scutellum; a very minute one at each basal angle of the scutellum and the basal angles of its apical field; three on the clavus, the median of which is larger and irregular; and five on the corium, one basal, a larger median one almost divided in two, and three beyond this is a transverse row forming a line with the posterior spot on the clavus, the two near the costa very small; the spots in the terminal row are more open, showing the minute dots on the pale ground plainly. The red color on the elytra terminates very abruptly with a broken indistinct brown line; the apex of the elytra beyond this line pale yellowish hyaline, immaculate, with the nervures indistinguishable. Apex of the wings pale yellowish hyaline, the base beneath the red portion of the elytra clear smoky hyaline, iridescent. Beneath white with the clypeus and a point on the disk of the plates of the male black; disk of the venter embrowned.

Vertex strongly angularly produced, the anterior edge thickened and rolled over on to the base of the front; apparently notched above the base of the antennæ. Front strongly depressed, flat and horizontal and sunken below the level of the cheeks and tumid basal margin. Length 2½ mm.

Described from one male taken at Hope Gardens near Kingston, April 18th, the last evening of my stay on the island. In this example the base of the scutellum has been somewhat injured and the square basal spot may be in the form of two parallel longitudinal vittæ. Prof. Baker in describing the type species says: "Face in the single specimen collapsed in drying", my specimen however is a well developed adult and I believe the sunken face to be characteristic of this genus which is very distinct in its general facies from any other known to me. It was founded in 1899 (Psyche viii, p. 402,) for the reception of the Brazilian species, *Smithii* Baker. Later (Invertebrata Pacifica i, p. 7, 1903,) Prof. Baker described a second species, *notata*, from Guatemala.

Protalebra apicalis n. sp.

Soiled white marked with black, orange, and pale yellow. Head ivory white; vertex quite strongly produced and angled before, convex; ocelli distinct; basal joint of the antennæ tinged with yellow. Pronotum one and one half times as long as the vertex; hind margin distinctly concave, the posterior angles prominent, subacute; orange, with the deflected sides and a large rounded median spot resting on the base whitish. Scutellum ivory white with the small basal angles brownish. Elytra whitish hyaline; a basal curved band on the clavus following the sutural margin from the base to about the middle where it is abruptly deflected to the commissure, and a small spot just beyond this on the corium against the claval suture, sometimes vaguely extended basally in a broken band parallel with that on the clavus, orange; apex of the elytra from just before the transverse nervures fuscous, with the nervures yellow and the disk of the areoles mostly hyaline; the extreme apical areoles are bordered with blackish; before this fuscous apical area are some vague pale lemon yellow marks covering the apex of the clavus and forming a broken oblique band toward the middle of the costa. Beneath and legs white with the apex of the abdomen and genital pieces yellowish. Last ventral segment of the female long, quite strongly produced in the middle where it is minutely tipped with brown; sides of the pygofers sometimes with a curved vitta; plates of the male long triangular, their sides straight and ciliated and their subapex with a triangular blackish mark. Length 3½ mm.

Described from one male and five female examples taken at Mandeville, April 1st. In its pattern of marking this species seems to be allied to [illegible] Baker from Nicaragua, (Invert. Pacifica i, p. 5, 1903,) but the colors are much paler and it certainly is a *Protalebra* as the marginal vein of the wings is returned but a short distance around the apex.

Protalebra bifasciata Gillette.

(Proc. U. S. Nat. Mus. xx. p. 711, 1898.)

I took one example of this very distinct little species at Rock Fort on March 25th. This has the black spot on the scutellum and base of the clavus very intense but narrow, not reaching more than half way to the costa. The types were from Brazil.

Protalebra omega n. sp.

Near *vexillifera* Baker. Smaller than *apicalis*; marked with white, orange and golden brown. Vertex quite convex and strongly produced, whitish with two approximate points behind the apex and a large discal spot dusky. Pronotum milk-white; a large oval orange spot occupies the apex anteriorly, deflected sides behind the eyes including the humeral angles reddish orange. Scutellum fulvous at base, whitish at apex, with the slender edges and apex minutely black. Elytra light golden brown with a broad curved milk-white vitta beginning on the claval commissure just behind the tip of the scutellum, touching the costa at about its middle, and then deflected inwardly and backwardly where it becomes narrower and terminates just before the middle of the transverse nervures. This white vitta is slenderly bordered with black exteriorly at base and with fuscous within and exteriorly at apex, and with the elytra closed forms a conspicuous and almost perfect mark the shape of the Greek letter omega; Apical areoles hyaline, a little smoky at tip and bordered costally by a curved fuscous marginal vitta which is deepened to a black spot on the node. Beneath and legs whitish; the posterior tibiæ dotted with black. Last ventral segment of the female strongly triangularly produced almost to the middle of the pygofers, the latter with stout black and white bristles. Length about 2 mm.

Described from two female examples taken at Rock Fort, March 25th. This is a small but very pretty species that must be related to *vexillifera* of Baker, but it is quite distinct.

Protalebra octolineata Baker. (Invert. Pacifica, i, p. 7, 1903.)

Two males and two females of this neat little species were taken at Rock Fort at Kingston. I also found it in numbers on Lantana bushes along the path to the office of the Hope Gardens. In my examples the vertex is soiled yellowish with the median line darker; a line either side of this and another adjoining each eye paler. The common dark median line of the pronotum and scutellum is bordered on either side by paler; anterior submargin of the pronotum with a narrow pale yellow callous and there is a smaller one behind each eye; the calloused slender lateral edges whitish. The four parallel slender black lines on the elytra are well described by Baker but he fails to say that the included area between them is whitish hyaline where it crosses the disk of the elytra. The transverse lines on the apical areoles seem really to be one line strongly folded on itself, forming a large transverse loop in the apical areoles, at the costal end of which is a fuscous cloud. The extreme apex of the elytra has a narrow fuscous marginal vitta. Wings faintly smoky hyaline with fuscous nervures. Tip of the rostrum and tarsi and apex of the hind tibiæ and a large spot on the prosternum black. Apex of the pygofers of the male and of the oviduct of the female, and a transverse cloud at the apex of the last ventral segment of the female, black. Sometimes the pale markings on the vertex and pronotum are almost obsolete, but the dark median vitta and the black lineations seem to be constant. Although more strongly marked than Baker's specimens from Nicaraugua and Mexico seem to have been I have no doubt but they represent the same species.

Protalebra brasiliensis Baker. (Psyche viii, p. 405, 1899.)

I found this insect very abundant everywhere in the warmer parts of the island, especially about Kingston. These have an abbreviated brown vitta on the base of the vertex, and the hyaline spots in the fuscous areas of the elytra are larger and regularly placed: two on the median transverse area, one at the tip of the clavus, another near this on the corium and the third larger resting on the costa and usually tinged with yellow; and three on the apical area, two medial, and a larger one on the costa; and the extreme apex is usually whitish. I have received exactly this same form from Mrs. Annie Trumbull Slosson, taken at Lake Worth, Florida. All these agree so closely with Baker's description that I feel little doubt of their identity. The concavely arcuated posterior margin of the pronotum with prominent posterior angles seem to be characteristic of this genus.

Empoasca mali LeBaron.

[illegible] near Kingston, [illegible] Mandeville, one [illegible]. These [illegible] with [illegible] United States [illegible]

Empoasca flavescens [illegible]

[illegible] appears to [illegible] me by [illegible]

Empoasca sp.

One example taken at Montego Bay, April 8th seems to belong to a still undescribed species. It is near the preceding but has the vertex a little longer and fuller and the base of the front suffused with yellow. Among the material taken at Mandeville is one more large specimen, apparently an *Alebra*, too immature for determination.

Typhlocyba pseudo-maculata Baker.

(Invert. Pacifica, i, p. 8, 1903.)

One pair of this obscure little species was taken at Rock Fort. They agree in every respect with Baker's short description and I have no doubt of their identity. The female has the extreme apex of the oviduct black.

Additions

The following species were omitted from their proper place in the list:

Edessa bifida Say.

Not uncommon at various places on the island. I have records of Mandeville, Balaclava, Appleton and St. Margaret's Bay.

Podisus sagitta Fabr.

I found this species fairly abundant at Rock Fort near Kingston, Mandeville and Balaclava and took one example at Hope Bay.

Pachygrontha bimaculata Distant.

One example taken at Port Antonio in a little grave yard on Richmond Hill, April 12th. This specimen differs from Distant's short description only in having the apex of the third antennal joint concolorous. It has the sides of the pronotum rectilinear a character not mentioned by Distant but one which would ally it with *longiceps* Stal, but its small size and general characters are so close to those given by Dr. Distant for his *bimaculata* that I prefer to place it there.

Index to new genera, species, etc.

This index includes the names of new genera, species and varieties described in the preceding pages, new names proposed, and also the names of the new genera and species described by Dr. Reuter from material taken by me in Jamaica and recorded in this paper.

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VOLUME VIII No. 6

BULLETIN

OF THE

Buffalo Society of Natural Sciences

ORGANIZED DEC 5th 1861

HISTORICAL SKETCH

BY

HENRY R. HOWLAND

BUFFALO, NEW YORK
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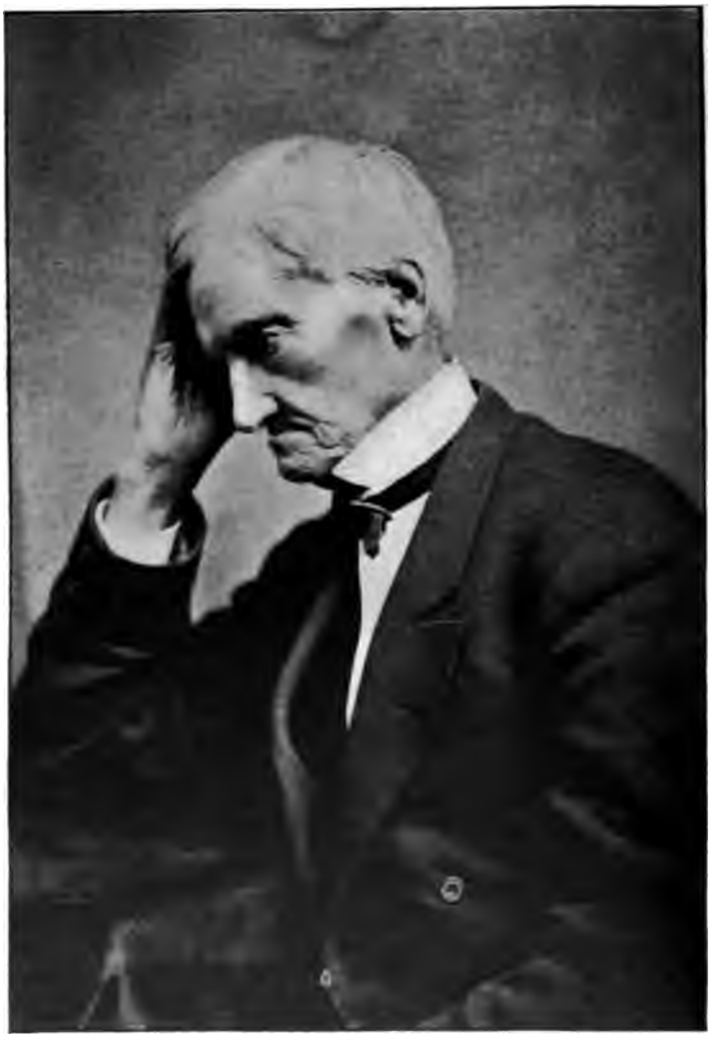

Hon. GEORGE W. CLINTON

First President Society of Natural Sciences

BULLETIN
of the
Buffalo Society of Natural Sciences

VOLUME VIII No. 6

The
Buffalo Society of Natural Sciences

HISTORICAL SKETCH

by
HENRY R. HOWLAND

The earliest effort in the City of Buffalo to organize a society for the study of Natural History dates back to April 10, 1858 when eight or ten boyish enthusiasts agreed to meet every Thursday evening, for interchange of scientific observations, at a room in the Granite Block on Main Street, where they discussed the first chapter of Genesis, the value to science of Hugh Miller's labors or those of Dr. Edward Hitchcock and other like grave subjects and out of their slender funds subscribed for the Scientific American and the Horticultural Magazine to aid their budding endeavors.

At first they called themselves "The Buffalo Natural History Society", but that did not suit them and after changing their title to "The Buffalo Scientific Society" and trying its effect for a few months they finally decided to be known as "The Lyceum of Natural Science" a name which they retained during the year or two of their somewhat brief existence. In April 1859 they rented a room in the Harvey Block for $25.00 per annum and continued their meetings until December 14th of that year when they determined to give up their room "unless circumstances become more favorable to our continuance in it than they are at present". Apparently "circumstances" were adverse, for here their meetings ceased; but among these early devotees of science were Henry S. Sprague, Wm. M. Stewart, James H. Hall and Edward C. Taintor, who a little later shared in the organization of the Buffalo Society of Natural Sciences.

Already reference had been made at some of their meetings to the formation of a new Scientific Association, but the thought seems to have slumbered until at the suggestion of Coleman T. Robinson six enterprising young men met on the evening of October 5, 1861 at the studio of Charles Caryl Coleman on East Swan St. near Main, where the Ellicott Square now stands, to discuss the organization of "A Natural History Society". Those present constituted themselves a committee to further the project and when they met again a week later they reported 113 names for possible membership. Other preliminary sessions followed and Thursday evening, November 21, 1861 a larger meeting of those interested was held at Odd Fellow's Hall when a form of Constitution and suitable By Laws, submitted by R. W. Haskins, David Gray und Coleman T. Robinson who had been appointed a committee for that purpose, were discussed, a primary election held and a call issued through the newspapers for a general meeting at Lower St. James' Hall on the evening of Thursday December 5th.

At this meeting Judge Clinton presided. The constitution was adopted, its first provision being that the Society should be called the "Buffalo Society of Natural Sciences" and its object "the promotion and study of the Natural Sciences, through the formation of a museum and library, the procurement of lectures and by such other means as shall be efficient and desirable for that purpose". At this meeting Hon. George W. Clinton was made president and for twenty years he was annually elected to that office. The others then chosen as the Society's first officers were–

1st Vice President . .	Rev. A. T. Chester, D. D.
2nd " " . .	Charles Winne, M. D.
Corresponding Secretary .	Samuel Slade.
Recording Secretary .	Theodore Howland.
Treasurer . . .	Leon F. Harvey, M. D.
Librarian . . .	Richard K. Noye.

The nine curators first chosen, who, with the officers made up the Executive Board for management of the Society's affairs were, George E. Hayes, M. D., Prof. William S. Van Duzee, Hiram E. Tallmadge, Charles D. Marshall, Coleman T. Robinson, Charles C. F. Gay, M. D., Charles S. Farnham, David F. Day and Charles F. Wadsworth.

COLEMAN T. ROBINSON

Among the first charter members besides those named, were, Dr. C. W. Harvey, L. G. Sellstedt, O. H. Marshall, Charles Caryl Coleman, Solomon G. Haven, Thomas Farnham, Walter Clarke, David Gray, Ottomar Reinecke, Dr. James P. White, Augustus B. Fitch, George P. Putnam, John Howcutt, R. G. Snow, Eugene N. Robinson and the four young men already mentioned as having belonged to the earlier "Lyceum of Natural Science". Within a year about one hundred names were added to the local membership including Henry A. Richmond, Augustus R. Grote, William H. Glenny and many beside who have proven steadfast friends to the Society.

These were days of first beginnings and many discouragements, but those charter members had the enthusiasm of youth and were not easily disheartened. The first lecturer was Professor Benjamin Silliman of New Haven who came for the evenings of February 19th, 20th and 21st, 1862. St. James' Hall, successor to the old Eagle Theater, had been burned on the 9th of January and presumably these lectures were given in the rooms first occupied by the Society on Erie St. in the building since used by Rogers Bowen and Locke and their successors. An old diary tells us that notwithstanding the hardest snow storm of the winter which raged on the first evening, quite a number of ladies were present and on the other evenings there was a larger and deeply interested audience.

About April 1, 1862 other rooms were secured over the New York and Erie Bank on West Seneca Street near Pearl. Here the Museum was fairly started in cases provided by Coleman T. Robinson. Augustus R. Grote contributed 600 specimens of Coleoptera collected in the State of New York and a like number of catalogued species of plants collected in the Rocky Mountains by Elihu Hull and J. P. Harlan.

Wm. W. Stewart was placed in charge of the Museum which grew so rapidly that soon the Seneca Street quarters were inadequate and more commodious rooms were taken in the third floor of the Jewett Building on Main St. opposite St. Paul's Church, where the collections might be better displayed.

On the 23rd of January 1863, the society was incorporated under the general Act of April 12, 1848 for the incorporation of scientific and other societies, the certificate being signed by Hon. George W. Clinton, Theodore Howland, Leon F. Harvey, Coleman T. Robinson, David F. Day, Henry A. Richmond, Charles D. Marshall, H. E. Tallmadge, Dr. Charles D. F. Gay, William W. Stewart and Rev. Albert T. Chester.

Shortly thereafter came the most important change in the early history of the Society. The Young Men's Association of Buffalo, organized in 1836, had always occupied rented quarters and at this time their rooms and their fine library were located in the American Block. They had long felt the need of more ample accommodations, but the early days of the great Civil War were too full of trying vicissitudes to encourage plans which they had cherished for securing a building of their own. Public confidence was shaken, finances were unsettled and doubt and anxiety prevailed. With the opening of 1863 the skies seemed somewhat lighter, there was at least comparative prosperity and the preliminary negotiations for a building project were begun.

April 17, 1863 the Executive Committee of the Young Men's Association adopted a resolution authorizing their Building Committee to confer with the other societies of Buffalo of a kindred character with reference to constructing a building which would accommodate the several organizations.

Accordingly in response to their invitation, on the 25th of April a Committee of the Society of Natural Sciences consisting of Judge Clinton, its President, David F. Day and Coleman T. Robinson were appointed for conference and July 9th it was resolved: "that this Society hereby elects to participate in the erection and occupancy of the proposed building for the use of the Young Men's Association, the Grosvenor Library and other institutions of the City and to aid in the raising of the funds necessary for that purpose". These negotiations finally ended in the purchase from Mr. A. Brisbane of the property known as St. James' Hotel and St. James' Hall, at the corner of Main and Eagle streets, having a frontage of about 100 feet on Main St. and running through to Washington St. for which the sum of $112,000.00 was paid.

In soliciting the subscriptions for the purchase funds the members of the Society of Natural Sciences enlisted heartily and many of the generous subscriptions were given by them, the assurance being made that they should receive adequate accommodations for their needs.

CHARLES LINDEN

Director of the Museum

At this time subscriptions to the amount of $81,655.00 were secured, the property purchased, such alterations made as were necessary and January 10, 1865 the new buildings were occupied and the Society of Natural Sciences found itself housed under the same friendly roof with the Library, the Academy of Fine Arts and the Historical Society. The Society's modest collections were attractively displayed, a fine portrait of its President Hon. George W. Clinton, painted by L. G. Sellstedt was presented to adorn the walls by the artist, who was himself an active member, and by Coleman T. Robinson who showed still further his warm hearted interest by contributing his own collection of marine shells to form the nucleus of the large and valuable conchological exhibit now owned by the Society; an extensive and beautiful collection of minerals was given by Mr. Charles F. Wadsworth; new members came in, a larger interest was awakened, the collections grew more rapidly and despite its very limited financial resources, the scientific work accomplished from year to year amply justified the self-sacrificing efforts of its friends. Many will remember the tower over the St. James' Hall building and its beacon light when Judge Clinton worked late at night over his scientific studies.

During the Civil War many of those who were its founders volunteered in their country's service and as its members met there was often present with them the remembrance of hushed voices and the thought of unreturning feet, but when those years of storm and stress were over and days of peace once more returned, the Society met its first great loss in the death of Coleman T. Robinson who had been one of its first founders and from the beginning one of its most generous friends. An active business man, he was still deeply interested in scientific studies and especially devoted to entomology and conchology. At the time of his death he was engaged in the banking business in New York City. By his will he bequeathed his library, his microscope and his collections to the Society and also the sum of $10,000.00 as the beginning of a permanent endowment fund.

Accordingly on the 13th of February 1874 Dexter P. Rumsey, George E. Hayes and O. H. Marshall were appointed as Trustees of the Permanent Fund, then consisting of the amount of Mr. Robinson's bequest together with the sum of $500 accrued from ten life memberships. By slow degrees this has grown so that there is now $24,827.50 in the hands of the trustees.

August 20, 1866 Charles Linden was appointed by the Society as its custodian, thus beginning a connection, the memory of which is cherished by all who knew him and marked by the beautiful bronze tablet with bas-relief portrait which occupies a prominent place on the walls of the Museum. Charles Linden was an extraordinary man. Born at Breslau, Germany, about 1831, educated first at the gymnasium there and then taught by his own efforts in the book of nature, both as a student and later as a teacher of science he was an enthusiast who had the rare gift of inspiring others.

Modest and unpretending in his ways, a seafaring life led him to the American lakes and to Buffalo where he found friends. Among these was Mr. Ottomar Reinecke, one of the Society s founders and himself a veteran naturalist, who quickly recognized his capacity for scientific work and brought him to the attention of the Society and its President Judge Clinton, so that his appointment soon followed. Three years later he was called to the Central High School as teacher of science and as such continued until his death February 3rd, 1888. For seven years however, he was the Custodian of the Society's collections and labored faithlully for their growth and for its welfare. It was through his efforts that the Bodemeier Collection of birds was brought from Europe and secured for the Society, the members of the Board of Managers subscribing at one of their meetings the necessary amount for its purchase. Each year as summer came the spirit of the explorer seized him and he wandered now to Florida, to Hayti, to Europe, to Brazil, to Labrador, to many strange and out-of-the-way places whence he returned always richly laden with additions to the Museum collections. No man was ever more beloved by his pupils and his friends. Earnest, unselfish and helpful, the uplift of his example cannot be forgotten.

In 1901 a bronze tablet in memory of Charles Linden was placed upon the walls of the Central High School and in the appreciative address made on that occasion by Mr. Henry P. Emerson, Superintendent of Education, he said

"As a teacher Mr. Linden was remarkable for patient industry, for original methods of presenting truth, for his familiar and Socratic intercourse with his pupils, and for unswerving

AUGUSTUS R. GROTE

Director of the Museum

loyalty to the school he served. There was a freshness in his instruction as of nature herself. He was a Thoreauan in his love of the fields. Frequently he went outside of the matter given by ordinary writers and gave the pupils the valuable information he had gathered in his own travels. His enthusiasm, devoted, not to his own advancement, but to the improvement of mankind, exerted a salutary and quickening influence on his pupils.

"Another characteristic was his simplicity and modesty. Placing a high value upon results, he cared little for methods and ceremony. Regarding knowledge and truth as everything, he sought for them and made them known without bringing himself forward. He had literally no thought of self-advancement. He liked plainness and frankness; was genuine and transparent; incapable of insincerity or indirection.

"Mr. Linden was no slave to conventionality; possibly he cared too little for appearances. To some he seemed peculiar, but his peculiarities were doubtless exaggerated in the mouths and minds of those who did not understand him. At least they were not affectations, but like himself, perfectly spontaneous and sincere. He was an "interesting" man. What casual observers called eccentricities, those who know him better considered marks of a strong individuality. He was a "character" in the special meaning of that word– "one of those pieces of nature's workmanship which are malleable by no external influence of culture, society or circumstances". Such men always speak from within and echo no man's opinions. When such a man is a teacher he will be interesting and will strongly impress himself upon his classes, whatever deficiencies he may have; and this Mr. Linden did.

"His nature was thoughtful and philosophic. He was a constant reader, an original thinker upon the historical, scientific and social problems that attract thoughtful men. I was more than once surprised to find how familiar he was with some particular epoch of history. His comments and criticisms on men and events were interesting and generally just No man or woman without somewhat similar tastes could know him.

"He was not to be lightly gauged by outward manner or appearance. Those who did know him, as they now look back, treasure the recollection of his look, his figure, his voice, his abstracted air as he walked the streets, his hearty laugh at an amusing mistake in the class-room, his beaming face as he displayed some specimen, under the microscope, to his class assembled round him.

"His character was well epitomized in a few words spoken by Rev. Herbert G. Lord at his funeral: 'While other people were striving for money and to make a show in the world, this man had plodded through life in an unobtrusive way, content to learn, to know and teach'."

It was while Charles Linden was Custodian that the Field Club was organized as one of the branches of the Society's work. At the Society's meeting of May 3, 1872 a resolution was adopted requesting Mrs. George Hadley, Mrs. George L. Squier and Miss Mary L. Wilson to organize such a Club for the out of door study of the Natural Sciences and to arrange the days and places for field meetings, promising cordial aid for their work. In this Judge Clinton and Mr. David F. Day were deeply interested and on their field days Mr. Linden would accompany the club members, stirring up their enthusiasm by his own ardent interest, thus establishing a happy relationship which continued so long as he lived. This Club has now had an active existence of thirty-five years.

Among the early members of the Society had been Augustus R. Grote, who had however removed from Buffalo and had already become quite famous in scientific work, especially in connection with entomology. When Mr. Linden's duties as teacher became enlarged so that he could not give so much time as he desired to the Society's affairs, Mr. Grote was invited by the Executive Board by resolution of January 15, 1873, to return to Buffalo to become Librarian and director of the Museum. The invitation was accepted and Mr. Grote at once entered upon his duties. He was a naturalist of rare ability and of recognized reputation, young and enthusiastic, of sensitive nervous temperament, a poet and musician as well as a devotee of science and the impetus which had been given to the Society's work and to the increase and proper arrangement of its scientific collections during the seven years of Charles Linden's custodianship was greatly furthered in the seven ensuing years during which Mr. Grote was the director.

By correspondence and exchange and by active field work the collections were rapidly increased. In his own favorite field of research his active efforts built up for the Society the famous collection of moths which bears his name and which at his earnest

GEORGE E. HAYES, M. D.

President Society of Natural Sciences

request was generously presented to him by vote of the Society when he left Buffalo in 1880. This collection was afterwards purchased by the British Museum which was eager to acquire it. In that custody it now remains, a memento of one part of the Buffalo Society's work in the advancement of Science. Some idea of its worth and of the thoroughness of Mr. Grote's scientific work may be shown in the fact that of the 1330 species in Grote's check list of North American Noctuidae, the collection included 1068 species and 2355 specimens of which 505 were type specimens.

These early days of Clinton and Day and Reinecke and Linden and Grote, and their associates had grown into busy active years of intellectual growth for the Society and under such guidance it had crept into the front rank among scientific organizations. At every meeting papers of great interest were read, covering the scientific subjects which were then enlisting the attention of the world.

In 1873 the Society began its publications, its first issue being Vol. I, Part I, comprising four important entomological papers by A. R. Grote. The four parts that make up the first volume were issued by March 1874, and contained no less than 16 scientific articles by Mr. Grote, with other valuable original papers by Peck, Willey, Morison, Scudder, Hartt, Rathbun, Harvey and Le Conte. From that time onward, the Society has continued its publications, embracing in them much important original material by distinguished scientific writers, thirty-four of the articles coming from the pen of A. R. Grote and including also the valuable botanical check lists compiled by David F. Day from personal observations made by Judge Clinton and himself, illustrated descriptions of the rare water lime fossils of this vicinity and many others of great worth. The Society's published bulletins are exchanged with Scientific Societies throughout the world, those of later years including the "Geology and Palaeontology of Eighteen Mile Creek" by A. W. Grabau, an exhaustive study, profusely illustrated and of high value, as is the later volume by the same author, a "Guide to the Geology and Palaeontology of Niagara Falls and Vicinity".

The Society of Natural Sciences was perhaps the first of Buffalo's institutions to bring an important convention within our city's gates.

The American Association for the Advancement of Science had been compelled by the vicissitudes of the Civil War to discontinue its meetings after that held at Newport, R. I., in 1860. In August 1866 at the invitation of the Buffalo Society it held its fifteenth meeting in this City, its sessions being held in St. James' Hall and in the rooms of the Young Men's Association in the American Block. It was welcomed to Buffalo by Judge Clinton in an address in which he claimed for our good city "a deep respect for literature, for art, for science, and a longing to make it as famous in letters as it is prosperous in commerce and manufactures". The meeting which lasted several days proved to be very interesting and once more the American Association was started on its forward career and when, ten years later, the Buffalo Society again extended its invitation to the great Association, it remembered the earlier kindness and accepted gratefully, holding its twenty-fifth meeting here during the week beginning August 23rd 1876. That was a famous meeting. The Centennial Exposition at Philadelphia had brought many savants from foreign countries who were present here in numbers and Thomas A. Huxley addressed the Association in the Common Council Chamber where the general meetings were held; the sectional meetings finding suitable rooms provided at the Central High School. There were reception parlors arranged at the Tifft House and evening sessions at St. James' Hall. Our good people flocked to these gatherings where they might hear from some of the greatest minds in the world. The effect of the meeting was all that could be desired. It left behind it an enthusiasm for study and perhaps for a time at least, many of our young men forgot their more material strivings in a new found eagerness for the things of the mind and the spirit. Again, in 1886, the American Association accepted our Society's invitation and met here at a time when the new building which it now occupies was being erected, and still once more in 1896 for the fourth time, the Association came here to hold its forty-fifth annual meeting and were welcomed by Dr. Roswell Park, then President of the Buffalo Society.

At all times the financial resources of the Society have been very limited and it is a matter of no small wonder that, notwithstanding this, so much has been accomplished in scientific work. The annual dues from members have never been

LUCIEN HOWE, M. D.

President Society of Natural Sciences

large in amount and oftentimes discouragement has stared us in the face, but some plan would be suggested for raising such funds as were absolutely necessary, such for example, as the Horticultural Fair held in 1866, to provide the money needed for entertaining the American Association; but most frequently when bankruptcy seemed imminent, a committee would start out with a subscription paper headed by themselves and public spirited men of Buffalo were not appealed to in vain.

From the outset the library and collections of its Museum had always been freely opened to the public; valuable scientific papers were read at each semi-monthly meeting of the Society and while still continuing these, in January 1876, the Society began its first public educational work by inaugurating its popular lecture courses which have been regularly continued each year since that time. For several years they were given in the Assembly room of the Central High School and in their earliest days the able members of the Society were the first lecturers. The initial course of ten lectures began with an excellent address by Judge Clinton enlightening his hearers as to the work of the Society and its possibilities. Then followed the familiar names of Grote and Linden, Larned and David Gray, Pitt and Kellicott, Milburn and Prof. William B. Wright and others, repeated and added to from year to year until there was sufficient money available to bring some distinguished savant whose name might add lustre to our native gold.

The effort to interest the people was timely and soon showed results, for in 1878, for the first time, an attempt was made to introduce into the city grammar schools elementary scientific studies, and it is recorded on the minutes of the Society that at a meeting held April 11, 1879 a resolution was adopted heartily commending the experiment and urging the school authorities to continue the effort to instruct the children in the elementary facts of the natural Sciences.

April 9, 1880, to the great regret of his many friends, Mr. Grote tendered his resignation as Director of the Buffalo Society of Natural Sciences which was reluctantly accepted. His scientific work had been and continued to be of the highest value. To the first three volumes of the Society's publications his contributed articles included his descriptions of North American Moths and his check list of the Noctuidae of this country.

While here he also edited the volume (in twelve numbers) of the North American Entomologist, published by Reinecke, Zesch and Baltz of Buffalo, a creditable publication, as among its contributors were many distinguished students of entomology.

After leaving Buffalo he took up his residence abroad, living at Bremen and later at Hildesheim in Hanover where at the time of his death September 12, 1903, he was director of the Roemer Museum. The American Entomologist (November 1903) says of him "He was an authority on the entomological fauna of Western New York State, particularly the region about Buffalo, but will be best remembered for his systematic work on North American Noctuidae. He described numerous species of Lepidoptera, aggregating over a thousand. His work made a great impression on our literature of the subject and was painstaking and accurate. His descriptions are good and his species well known. He will undoubtedly, be classed as one of the greatest students of American Lepidopterology. His catalogues were most valuable and universally used."

A still greater loss befell the Society when, on the 13th day of January, 1882, Hon. George W. Clinton, who had been its President for more than twenty years tendered his resignation, as he was about to take up his residence in Albany to enter the service of the State as the editor of the Clinton Papers. In all these years of faithful loving service, the Buffalo Society of Natural Sciences had become to him as his own child and he had become endeared to its members with a peculiar affection. The success of the Society has been largely due to his spirit and his labors. One who remembers those days writes of them, "I look backward and I see a long table in the assembly room and a kind looking, gaunt old man, with fine rugged features and pale blue eyes is resting his hands upon the table before him and talking to a lot of attentive disciples. He has presided that day over the Superior Court, now, like him, alas, no more, and has ruled upon exceptions and allowed or disallowed them in some important law suit, and now he has turned his back upon the dry dust of the law and is talking to his auditors about the fauna and flora of this end of the State, and all pay reverence to the Chief Judge who is deep in philosophy and nature-study and loves things as they are and not as the wills and caprices and imaginations of men would make them out to be."

LEON F. HARVEY, M. D.
President Society of Natural Sciences

The great Clinton Herbarium which with the enormous labor of years he built up for this Society and which includes more than 24000 exhibits, is a testimony to the unselfish satisfaction which he ever took in his devotion to its interests. Its indebtedness to Judge Clinton cannot be measured by words. The whole community felt the influence of his spirit. As his friend, Hon. James O. Putnam once said, "He was our universal educator. Not to speak of his eminent professional career, he has taught us the sweet humanities and that unbought grace of life, which are the highest and purest charm. Nature's own child, he has unfolded to us her mysteries, as she has revealed them to him, from tree and shrub and flower and her myriad schools of life. For him, nature unveiled her face and filled his ear with music and his soul with all pervading harmonies."

Judge Clinton was a man of deeply reverent feeling. His was no inconoclastic spirit that could rejoice in breaking down rather than in building up. A true scientist, he had no fears for the safety of a demonstrated proposition and was ever glad to welcome investigation and growth and new knowledge. "True it is" said he in one of his addresses, "that no one can verify all facts and we must take many things on trust; but in investigation of any it is dangerous to be wedded to a theory." So unproven conjecture never appealed to him and his convictions were based upon fact rather than upon hypothesis. He was simple, straightforward and kindly in his ways and in his speech and by his gentleness compelled the affection of all who knew him. Men loved him and his presence was a blessing.

His sudden death which occured at Albany three years later (September 7, 1885) seemed in keeping with his life. Wandering through the Rural Cemetery in the autumn afternoon, his life suddenly ended and he was found with some flowers in his hand which were buried with him. In the words of George William Curtis before the Board of Regents of which Judge Clinton was Vice Chancellor, "Nature seemed to have reclaimed the old man, whose heart the love of her had kept as warm and unwasted as a child's. Like Enoch, in that tranquil, beneficent, blameless life, he walked with God, and God took him."

He was succeeded in the Presidency of the Society of Natural Sciences by Dr. George E. Hayes who was elected February 18, 1882, though he held the office for a few months only as his death occured on the 5th of May in that year. He too had been one of the Society's founders in 1861, as he had been in 1836 one of the organizers of the Young Men's Association and one of its first Presidents. From the beginning he had been a very active member of our executive board and always most liberal in contributing to its support. Although quiet and retiring in his ways he always participated in the interesting discussions which followed the scientific papers read at the Society's meetings and two of his own lectures before its members, those upon the "Geology of Buffalo" and upon the "Origin of Life" have been published in pamphlet form as well as in the memorial volume issued after his death. His last public utterance was his inaugural address delivered February 17, 1882, upon taking office as President.

He was always profoundly impressed with the educational work which the Society attempted and with its possibilities and after his death it was found that under the provisions of his will, one third of the income of his estate was to be reserved as an accumulative fund until the death of his widow when the whole estate should be divided equally between his daughter and the Buffalo Society of Natural Sciences as an endowment for a free school of Natural Science "or for the purpose of advancing the interests of Natural Science in the City of Buffalo." There could be no finer gift to the cause of scientific education and no finer tribute to the unselfish devotion of the giver to that cause than is this noble benefaction.

At the time of Dr. Hayes' death, Dr. Lucien Howe, the First Vice-President became President and had the honor of reelection February 16, 1883, to by followed in 1884 by Mr. David F. Day, in 1885 by Dr. Leon F. Harvey and in 1886 by Professor D. S. Kellicott who held the office for three years. Professor Kellicott had long been an interested member of the Society and active in scientific investigation, contributing frequent articles to the various science journals, always illustrative of original work. In charge of the science studies at the Buffalo State Normal School it was mainly by his endeavors that the science building was added to its equipment. When he resigned in 1888 to become Professor of Zoology and Comparative Anatomy at the Ohio State University, Columbus, Ohio, his departure was deeply regretted by all who knew and appreciated the valuable service he had rendered to Buffalo.

Prof. DAVID S. KELLICOTT

President Society of Natural Sciences

For twenty two years the Young Men's Association Library, the Society of Natural Sciences, the Fine Arts Academy and the Historical Society occupied the old St. James' Hotel and Hall property at the corner of Main and Eagle Streets, but in the later years when the library and the several collections had grown to large and valuable proportions, there had developed a strongly increasing desire to see these possessions more safely housed and more adequately provided for in a fire proof building. In the autumn of 1882 steps were taken by nine public spirited citizens of Buffalo to secure from the Board of Supervisors the site once occupied by the old county buildings at the corner of Washington and Clinton Streets, which had been vacated in 1876. April 18, 1883 a meeting of prominent men was held at the residence of Mr. Sherman S. Jewett when a plan was submitted for erecting on that site a suitable fire proof building for the joint occupancy of the Library and its three sister societies. This plan met with such hearty approval that the undertaking was at once entered upon with vigor. At the meeting of the Society of Natural Sciences held April 24, 1883, a resolution was adopted "That the Buffalo Society of Natural Sciences most cordially approves of the project as one which will materially aid in forwarding the cause of education in this city. That a committee of five be appointed from this society to advise with and assist other committees appointed for this purpose. That we earnestly entreat all friends of our Society to forward this work in every way in their power, feeling that now is the time to place these institutions in a position which will make them an honor to the city, and will materially increase their powers of usefulness."

It was necessary that in addition to the funds to be obtained by a loan upon the Main and Eagle Street property, an additional $100,000.00 should be raised by subscription and in the campaign which now followed to secure this sum the members of the Society of Natural Sciences were earnest and actively vigorous in generous assistance. When the final appeal was made to the public at large, the result was a happy surprise to all concerned. A building fund suscription of $117,000.00 was secured, after much mutual conference plans were prepared and adopted and in January 1885, the contracts for the principal work were let. The noble structure which was to become not only an architectural ornament but a powerful moral force as well in this city slowly moved onward toward completion, and on the 7th of February, 1887 was formally opened to the public with fitting inaugural exercises. The venerable and beloved Bishop of Western New York, Rt. Rev. Arthur Cleveland Coxe, D. D. offered the dedicatory prayer closing with this solemn dedication.

"In the name of God, Amen: We pronounce this house opened and devoted to the good of human minds and spirits: and may the blessing of the Father and of the Son and of the Holy Ghost rest upon it, henceforth and forevermore. Amen."

Following the inaugural address of Mr. Jewett M Richmond, President of the Young Men's Association and that of Hon. Sherman S. Rogers of the Fine Arts Academy, Prof. David S. Kellicott, President of the Society of Natural Sciences spoke on its behalf, calling public attention to what the Society had accomplished in the first quarter of a century of its existence then just ended and followed his brief historical sketch by a consideration of some of the reasons, so far as the public is concerned, why it and its kindred societies exist, claiming justly that they are educators in the broadest sense and their purpose to encourage investigation, to discover and make known the facts and laws of Nature, that knowledge which becomes of more and higher importance as society advances, calling attention to the fact that here its discussions are public, its valuable collections and its large scientific library always freely open for profitable study, inviting the good people of Buffalo to a more thorough acquaintance and a deeper general interest in its work, ending with the words "The Society is your own, one of your educators, know it, respect it, cherish it."

There had been no small labor in moving the collections and their cases from the old building into the beautiful home now provided for them, but when this had been accomplished and the collections again arranged and displayed it seemed as if our public spirited men and women had indeed proved themselves to be that which Judge Clinton with prophetic eye had claimed for them in his welcoming address to the American Association in 1866 and had made good that "respect for literature, for art and for science" which he asserted as their attribute at that time. When the collections had been placed the rooms were formally inaugurated on the evening of June 14, 1887, when after proper words of welcome by the President Prof. Kellicott, an able address was delivered by Prof. Edward S.

Hon. DAVID F. DAY

President Society of Natural Sciences

Morse of Salem, Mass. who came at the generous invitation of Mr. Henry A. Richmond to speak on the purpose and value of Scientific Societies.

And so the Society found itself fairly embarked upon the second quarter of its useful life comfortably and safely housed and with renewed vitality. It seemed indeed an especial good fortune that the Young Men's Library and the collections of the three sister organizations were thus secured in safety, for on the 18th day of March, 1887, the building which they had occupied for so many years, regarding which its occupants had grown so fearful and which had now become "The Richmond" hotel, was destroyed by fire and the terrible loss of life which then occured cast a gloomy shadow over the whole community and all its rejoicings. It seemed a singular fact that this was the Library's second close escape from destruction, for the American block which it had occupied for several years was burned January 25th 1865, just fifteen days after the removal to St. James' Hall.

The rooms provided for the Society of Natural Sciences and now opened by it for free public use, were in the basement of the new building and included an assembly room for public. lectures and the Society meetings. Other rooms were devoted to geology, mineralogy, botany and the various exhibits of scientific possessions, one room being given to the remarkable collection of fossils from the water lime group near Buffalo presented by Mr. Lewis J. Bennett, so long the warm and generous friend of the Society, comprising 323 valuable specimens, and unique in the large number and variety of specimens of the Eurypterids of which many are types, making it the most complete and valuable collection of water lime fossils in existance. For sixteen years these basement rooms were the Society's home and as collections grew and the library increased in size it became impossible to find room and valuable exhibits were of necessity stored away until in 1902 the Buffalo Historical Society which had occupied the upper floor of the Library building found a new home in the beautiful marble structure which the State of New York erected in Delaware Park for the Pan-American Exposition. With their departure the Society of Natural Sciences was kindly permitted to occupy the upper floor as well as the basement, to the great relief of all concerned.

A new and more commodius lecture room was thus provided as well as better rooms for the Society's scientific library of about 5000 volumes, for the conchological exhibit and for the excellent archaeological collection of some 5500 specimens. This latter collection had grown from small beginnings to assume a representative character, gaining greatly by the generosity of Mr. Fred. S. Dellenbaugh, Dr. Ernest Wende, Mr. Frederick Houghton, Mr. D. M. Silver and others, by the acquisition of the unique collection of Chiriqui pottery, purchased for the Society by Mr. David F. Day, Dr. W. C. Barrett and Dr. Lee H. Smith, and the Riggs Collection of Mound Builder pottery obtained in 1891. At the close of the Pan-American Exposition in 1901 all of the African Village archaeological exhibits were secured for the Society by Mr. Edgar B. Stevens, Dr. Lee H. Smith and Mr. Robert R. Hefford.

The exhibit of mammals includes the finest group of the American Bison ever mounted, a superb group of Rocky Mountain Goats and a large number of other groups, scarcely less noteworthy All of these beautiful groups show the great skill of Mr. Herman Grieb the well known taxidermist who has been for many years a generous and faithful friend of the Society and its fellow worker. The cases for these groups as well as the greater portion of those used for the Society's collections have been made by Mr. H. W. Kruse of this city and show his always able workmanship.

The Ward collection of casts of fossil remains is of great value to students. The geological and the mineralogical collections are very comprehensive in scope and are being constantly increased. A recent accession is a splendid meteorite from the celebrated Canon Diablo, presented by Mr. Andrew Langdon in 1906. The famous Clinton Herbarium has been already mentioned as also the fine Bodemeier Collection of European Birds and in addition to this the collection of New York State birds is practically complete. The conchological collection includes a considerable number of types described and presented by Dr. Isaac Lea, as well as a complete collection of local species. The Kellicott collection of types of fresh water sponges is unique of its kind. The valuable reference Library of scientific publications contains over 5000 bound volumes and is being rapidly increased by the Society's exchanges.

HENRY P. EMERSON

President Society of Natural Sciences

After the resignation of Mr Grote as Director of the Museum, Charles Linden again assumed that responsibility and under his supervision Dr. Julius Pohlman acted as custodian and librarian until May 1890 when his resignation was accepted. Dr. W. C. Barrett was then made Director of the Museum and Miss Amanda M. Crawford was employed to arrange and classify some of the collections. February 11, 1892 Mr. Frederick K. Mixer was appointed Director and had charge of the Society's collections for seven years.

Mr. Mixer was a close and careful student of Geology and Mineralogy and classes were organized by him for science work and successfully carried on under his management. When he resigned, October 6, 1899, Miss Elizabeth J. Letson, who had for several years been engaged in special work for the Society was made Director of the Museum, an office which she still holds (1907) after a faithful service of fifteen years since she first entered the Society's employment. In 1905 the State Museum at Albany published a check list of the Mollusca of New York prepared by Miss Letson, who received the honorary degree of Sc. D. from Alfred University in 1906, and in recognition of its worth, she has now (1907) been commissioned to prepare a monograph upon the Land and Fresh Water Shells of New York State to be freely illustrated with colored plates and published by the State.

May 28, 1889, Hon David F. Day was elected President of the Society to succeed Professor Kellicott and held that office for three years. One of its original founders, the close friend and associate of Judge Clinton in their favorite study of botany in which both were famous, Mr. Day was from its first beginnings until he died, August 21st, 1900, a firm and steadfast friend to the Society of Natural Sciences and devoted to its highest interests. Deeply concerned in all Natural Science work, he was especially interested in studying the flora of Western New York and his check lists of the plants of Buffalo and its vicinity, published in the Society's bulletins are considered as authoritative and complete. Conservative in temperament, deliberate and thoughtful in action and speech, his conclusions were well grounded, logical and always worthy of consideration and acceptance by his fellow workers in the field of science, and in this Society which he had cherished and served so long, his loss was and is most deeply felt.

In 1892 Mr. Henry P. Emerson, Superintendent of Public Schools became President and was succeeded in 1893 by Mr. William H. Glenny who did much to further the successful work of the Society. From 1896 to 1899 Dr. Roswell Park was President, followed in that year by Dr. Lee H. Smith, always most actively concerned in the Society's welfare. For four years Dr. Smith was annually re-elected as President but in 1903 was succeeded by Hon. T. Guilford Smith, LL. D. who still continues in that office.

Himself a Regent of the University of the State of New York, and deeply interested in the cause of public education, chairman of the Museum Committee in charge of the scientific work of the State since his election in 1890, and a member as well of many institutional boards and public societies, Mr. Smith has done much to enlarge the scope of the Society's connections and correspondence with other similar organizations and to increase the extent of its public usefulness.

The Field Club, which began in 1872 was the earliest affiliated branch of the Society, but as the years went on other branches were organized and gradually the Microscopical Club, the Archaeological Club, the Agassiz Association, the Entomological Section, the Conchological Section and the Electrical Society came into existence as working parts of the parent Society which furnished the gathering place for their meetings and the generous use of its collections and apparatus for their studies. A constant disposition has been shown to co operate with any organization that has in view scientific research and public instruction.

Beginning with such names as those of Benjamin Silliman and Louis Agassiz in 1862, the Society of Natural Sciences has brought many famous men to Buffalo during the forty six years of its existence. Its lecture rooms have been crowded, often to repletion, by the good people of our city eager to hear the great men of science who have come, upon the Society's invitation, to honor us with their presence and charm us by their utterance.

In addition to the first natural function of the Society, the stimulation and encouragement of original research in the various departments of Natural Science, — endeavers in which it has been eminently successful, — its controlling purpose has always been to further the educational work of Buffalo by every

WILLIAM H. GLENNY

President Society of Natural Sciences

means in its power. To this end for nearly half a century its Museum and library has been opened to the people for their free use, and its popular lecture courses have been given each winter, upon scientific subjects which could interest the public and especially awaken the enthusiasm of our high school pupils and those of the upper grades in our grammar schools.

Every facility for study for these and for all students has at all times been freely placed at their command. The Society has always realized the important position which a great scientific museum should occupy in the educational system of our city and has always opened its doors freely to the public. The immediate result of the resolution adopted at the meeting of April 11, 1879, encouraging the tentative effort of the Department of Public Instruction to introduce elementary science work in the Buffalo grammar schools, was to bring the science teachers with their classes to the Society's rooms where the various collections were displayed for their convenience. Travelling collections of scientific exhibits were prepared and loaned to the schools. Then acting upon a plan first conceived by Prof. Frederick Houghton and Dr. Lee H. Smith, special lectures upon familiar topics of general interest for the schools such as "Bees", "Birds", and "Insects", were arranged and proved successful and from these beginnings our present educational work has been evolved A projection apparatus was added to the Society's equipment and employed to illustrate talks given by school principals or class teachers.

Finally in 1905, by arrangement with the Department of Public Instruction, the Society's rooms were placed at the disposal of the Superintendent of Education for the establishment of regular hours of instruction by illustrated lectures to the children of the public schools, these lectures becoming an integral part of the school requirements, the attendance of the grammar grade classes being made compulsory The services of Dr. Carlos E. Cummings, as lecturer were secured by the Society at its own expense and these courses of instruction in elementary science as given by the Society have now been carried on for three years with most satisfactory results. During the last year ending June, 1907, 190 lectures were given to a total attendance of 19731 public school children, the subjects being "Bees", "Birds", "Tropical Products", "Physiology", and "Coal and Iron". An exceedingly interesting and detailed account of these lectures written by Dr. Cummings was given in a bulletin published by the Society in 1906. The Society owns a valuable and most interesting series of nearly 2000 lantern slides which it has prepared for this most important branch of its work. It has been the pioneer among the Societies of Natural Science in establishing in this way a direct educational relationship to the public school system of a great city. Its success has awakened a wide spread interest throughout the United States and Canada: many letters of inquiry regarding our methods are constantly being received and other Scientific Societies in leading cities are already seeking to follow the example set them here. During the summer of 1907 Dr. Cummings has been invited by Dr. George E. Vincent of the Chautauqua assembly to deliver his lectures there, with an advanced course for Science teachers attending that summer school.

On the 13th of March, 1903, Mr. Dexter P. Rumsey and the heirs of Bronson C. Rumsey of Buffalo, conveyed as a gift to the Buffalo Society of Natural Sciences a plot of land having a frontage of 150 feet on Elmwood Avenue lying southward from the southerly boundary of Delaware Park with a depth of 280 feet to a proposed street that will be parallel to Elmwood Avenue. This beautiful property, valued at about $30000.00 was generously given as the site for a building suited to the Society's purposes. Plans for such a building have been prepared by Messrs. Green and Wicks and it is greatly hoped that in the near future the necessary means may be provided for its erection as a permanent home for the Museum, with the proper lecture rooms and laboratories for its educational work.

It is now forty-six years since the Buffalo Society of Natural Sciences was first organized. Of the one hundred and twenty nine members who joined in that organization but sixteen are still living, but, as the years have slipped by, the places of those who have passed away have been taken by others who have labored with zeal to maintain the high ideal of service which has ever characterized the Society's endeavors. It has grown from the smallest beginnings to the recognized position of influence which it occupies today. It is an educational factor of no small importance in the school system of our great city and has become a teacher to other scientific

ROSWELL PARK, M. D.

President Society of Natural Sciences

societies elsewhere who are glad to profit by our successful experience.

From the beginning the Society has had to contend with the adverse conditions of poverty. Its limited financial resources have often forbidden undertakings of great promise. Nevertheless, thanks to its faithful friends who have saved it from disaster, it has been able to maintain a highly honorable existence and to show a steady growth.

It is expected that the Hayes bequest will greatly assist in its educational work, and it is hoped that with this prospect of usefulness in sight, its membership may now be largely increased and that it may be enabled to undertake the duties that clearly lie before it with vigor and with the knowledge that its efforts will be widely acknowledged and generously sustained.

HENRY R. HOWLAND.

July 1, 1907.

The Trustees of the Permanent Fund

As has been briefly stated in the foregoing sketch, on the 13th of February 1874, Dexter P. Rumsey, Dr. George E. Hayes and O. H. Marshall were appointed as Trustees of the Permanent Fund which had its first beginnings in the generous legacy of Coleman T. Robinson. Upon their organization Mr. Charles D. Marshall was made the Treasurer of the Fund and through all the changes that have since occurred he has continued to hold that responsible office.

Any record of the Society's history would be incomplete that failed to pay a tribute of grateful appreciation to Mr. Marshall for the unselfish and devoted service to the Society's best interests which he has so freely given for more than thirty-three years. The watchful care of its investments has taken up no small portion of his time and attention, the burden naturally falling upon his shoulders. One of the original organizers of the Society in 1861, as well as one of its incorporators in 1863 his interest in its welfare has been unfailing and that interest has had its practical manifestation in the painstaking service of so many years. In this the Society has indeed been fortunate. Those who with Mr. Charles D. Marshall are now Trustees of the Permanent Fund are, Mr. William H. Glenny, Mr. Robert R. Hefford and Mr. H. H. Littell.

H. R. HOWLAND.

LEE H. SMITH, M. D.

President Society of Natural Sciences

ANNUAL MEETING

of the

Buffalo Society of Natural Sciences

May 17th, 1907

At the Annual meeting of the Buffalo Society of Natural Sciences held May 17, 1907 at which Hon. T. Guilford Smith, LL. D., President of the Society, presided, the President's address traced the growth and development of the Society from its small beginnings and dwelt upon the important educational work which it is now doing, the value of that work to this city in its co-operation with the Department of Public Instruction, in its free lecture courses and in its valuable scientific collections which are at all times open to the public. The recent Bulletin reviewing the work which the Society has done in co-operation with the Public Schools, has awakened a wide spread interest and other Cities than our own are following our example. In this great work we have taken the lead and it is planned not only to continue it but to extend the scope of its usefulness.

The reports of officers and committees were then submitted.

EDUCATIONAL REPORT.

The Report of the Committee on Education, in the absence of the chairman, was made by Dr. Carlos E. Cummings who stated that his work during the year covered 190 lectures given by him at the Society's rooms to the children of the Buffalo Public Schools, as shown in the following schedule.

No.	Subject	Grade	Date begun	Date ended	No. of Lectures	Attendance
I	Bees	7	May 14	June 1	24	2663

SUMMER VACATION.

II	Birds	7	Nov. 20	Feb. 5	47	3208
III	Physiology	9	Dec. 14	Jan. 11	13	515
IV	Tropical Products	6	Feb. 5	March 8	34	4862
V	Coal and Iron	5	March 13	April 18	30	3914
VI	Physiology	9	April 29	June 14	23	1477
VII	Bees	7	May 13	June 14	19	3092

Total number of lectures 190 Total attendance 19,731

All of these lectures are illustrated by the materials in our own Museum. In series I and VII a full hive with the bees at work is used, as well as an empty hive showing the frames, bee-cells, etc.. and a series of lantern slides illustrating the principal features of bee life as indicated by John Burrough's stories about bees, used in the schools as a reader.

In series II is used the fine set of lantern slides owned by the Society, illustrating birds and their homes.

The lectures on Physiology, series III and VI were tried for the first time last year and have proven to be the most popular in our courses. The State Regents require a certain amount of practical experimental work before the classes and as the Public Schools do not have adequate facilities for such work, the ninth grade classes have come to us for it. All the experiments required are given before these classes, the circulation of the blood in the tissues is demonstrated and when desired by the teacher, photo-micrographs illustrating normal histology are thrown upon the screen and explained to the pupils. The skeleton purchased last year has also been in daily use.

In series IV for the 6th grade the lectures are illustrated by the specimens of tropical fruits displayed in the cases and by numerous lantern slides of scenes in Jamaica and Mexico.

The lectures on Coal and Iron (Series V) failed somewhat of their purpose as a portion of these fifth grade pupils had not begun the study of United States Geography.

The Schedules for these lectures are prepared by the Department of Public Instruction and placed in the hands of the

Hon. T. GUILFORD SMITH, LL. D.
President Society of Natural Sciences

IV. OF MICH.

school principals and the spirit of hearty cooperation shown by principals and teachers alike has been most encouraging.

RECORDING SECRETARYS REPORT.

The Recording Secretary, Dr. Carlos E. Cummings, reported that as a delegate of the Society he attended the Tenth International Geologic Congress at Mexico City in August, 1906, visiting with other delegates the cities of Puebla, Oaxaca and Tehuacan, from which side trips were made to the interesting ruins of Mitla and the cactus country of Zapotitlan. During the sessions of the Congress which were held at the National Institute of Geology, trips were made to Cuernavaca, Pachuca and to the Pyramids of Teotehuacan. At the close of the Congress, he visited the coast, passing through Jalapa, Vera Cruz and Orizaba, following this by a thirty days' journey from Mexico City northwest to the American frontier and returning to the Capital. He was thus enabled to secure for the Society a large amount of exhibition material, illustrating the mineral resources of Mexico and also about a thousand photographic negatives from which about 700 lantern slides have been made for lecture work. As will be seen Dr. Cummings delivered four of the lectures in the general course, of which three were descriptive of Mexico, and one of the Island of Jamaica.

He also reported his trip to the Lake Superior Copper region in June 1906 when he visited the Calumet properties and other mines in the vicinity of Houghton, Michigan, securing many valuable exhibits of copper ores and interesting photographs.

As a delegate of the Society he attended the meeting of the American Association for the Advancement of Science at New York in December 1906, also representing the Society at the Memorial Services held at Wyoming, N. Y. in honor of the late Professor Henry A. Ward and at his funeral.

He reported that in addition to his lecture work for the schools he had added largely to our collection of lantern slides, which now numbers nearly 2000 pictures including the Mexican slides, about 300 referring to Jamaica, the remainder illustrating subjects of Nature study. Of these the series illustrating birds and their nests is especially fine and the Society is greatly indebted to Mr. James Savage for lending his splendid negatives of bird homes.

During the year several delegations of British school teachers visiting this country to inspect American methods of teaching, have been received at our rooms where they have inspected our collections, listened to lectures and have been greatly interested in our own methods of conducting educational work.

DIRECTOR OF THE MUSEUM.

The Director of the Museum, Miss Elizabeth J. Letson, reported the numerous donations to the Museum which have been made by generous friends during the year, including the valuable Meteorite from Cañon Diablo, Arizona, presented by Mr. Andrew Langdon, and the portrait of the late Prof. Henry A. Ward, given by his son.

As in past years the teachers of our public schools have made continuous use of our various collections and the loan or travelling collections furnished to all of the public schools have included specimens from nearly every department of our Museum. There is a constant demand for material for special nature work from the schools and from private teachers. Some of our collections, as for example, our birds, show the effect of this constant usage and may, ere long, require to be replaced.

The collection of birds' eggs has been catalogued during the year by the card system as used in libraries, there being also an accession register. The work of labelling and cataloguing the Conchological Collection is now in hand, the catalogue being about half finished.

Our inventory shows that the Museum contains 63,052 specimens in all its departments of which but 7,512 thus far have been entered in our new card system catalogue. It seems important that this catalogue work should be pushed forward as rapidly as our means will permit.

The Director of the Museum represented the Society in June 1906 at the Ithaca Meeting of the American Association for the Advancement of Science and again at the December Meeting in New York City. At this time all of the Departments of Natural History and Ethnology united in an exhibition given at the New York Museum of Natural History for the purpose of illustrating recent advances in the study of the natural sciences. By invitation of the Association our Society sent a collection of specimens from the water lime which attracted much attention in the exhibit of the Geologic section.

In September 1906 the Director of the Museum attended the International Congress of Americanists at Quebec and in April 1907, the Meeting of the American Oriental Society at Philadelphia. At the request of the Society she has also visited Chicago and Detroit in connection with her studies of certain groups of New York mollusks. In June 1906 the Director received the honorary degree of Doctor of Science from Alfred University.

TREASURER'S REPORT.

The Treasurer, Mr. Charles R. Wilson, reported as follows:

1906	RECEIPTS.	
May 11.	Balance on hand	$ 178.69
	Income from Permanent Fund	1102.27
	City of Buffalo	1000.00
	Membership Dues	713.00
	From Estate of Dr. George E. Hayes, decd., Amount due up to Nov. 21, 1906	55.83
	Borrowed from Manfrs. & Trad. Nat. Bank	2000.00
	Borrowed from Est. of G. E. Hayes, decd	1500.00
1907	Interest on Bank account	2.53
May 17.	Total amount of receipts	$ 6552.32

DISBURSEMENTS.

Salaries	$ 2645.00	
Lectures expenses	476.33	
Society rooms expenses	480.00	
Travelling expenses	430.75	
Museum supplies, material and repairs	329.40	
Stationery and Printing	438.89	
Gas and Electric lighting	170 40	
Insurance	183.60	
Postage	33.00	
Miscellaneous Expenses	104.30	
Commissions	92.20	
Estate of Geo. E. Hayes, dec'd, Int. on note	50.00	
Manfrs. & Traders Nat. Bank, Int.	370.87	
Chas. H. Ward, work on Inventory	150.00	5954.74

1907		
May 17.	Balance on hand	$ 597.58

PERMANENT FUND.

The Commissioners of the Permanent Fund, by Chas. D. Marshall, Treasurer, reported that May 17, 1907 the principal of the fund aggregated $24,827.50, of which all but $2677.50 is invested in bonds and mortgages and that the amount of interest moneys received during the year was $1102.27 which has been turned over to the Treasurer of the Society.

ROOMS COMMITTEE.

Mr. H. R. Howland, Chairman of the Rooms Committee reported that during the year just ended a very careful inventory had been made, begun by Mr. Chas. H. Ward of Rochester who had been employed for the purpose and completed by our staff showing the number of specimens in the Society's Collections and their value as follows:

Section		No of Specimens	Value	
A	**Ornithology**	1610	$ 4729.80	
B	**Conchology**	11481	1906.38	
C	**Ethnology and Archaeology**	5502	22457.85	
D	**Mineralogy**	1976	3437.50	
E	**Geology and Paleontology**	5210	7463.40	
F	Mammals	28	9546.25	
G	**Ichthyology**	242	540.50	
H	**Herpetology**	123	454.00	
I	**Entomology**	5347	1304.75	
K	**Botany**	24084	6075.00	
L	Economics Collections	7240	2690.55	
M	**Osteology**	110	636.25	
N	Miscellaneous	99	436.00	
	Total Numbers	63052	Value, $61678.23	$61678.23
Furniture, Cases, Portraits and Apparatus				7322.91
Library,	Bound volumes	4620	Value, $ 8372.00	
	Unbound "	300	300.00	
	Pamphlets	1245	124.00	
	Maps	22	22.00	
	Bulletins on hand	5962	Est. Cost, 4000.00	12951.50
	Total Number	12149	Value $16951.50	$81952.64

By this it will be seen that the Society's Collections with its Library and its furniture, cases, portraits and apparatus reach a total value of......	$ 81,952.64
To this add:	
Present amount of Permanent Fund...........................	24,827.50
Estimated value of land donated by the Rumsey Estate for permanent location.....................	30,000.00
Giving as our total assets at this date......	$ 136,780.14

Upon its possessions now in the Public Library Building the Society is carrying insurance amounting to $34,000.00.

During the past year a new system of electric lights has been installed in the lecture room, with a separate connection for the stereopticon by means of which the room can be instantly darkened or re-lighted without inconvenience to the audience. This system has been inspected by the Board of Fire Underwriters and pronounced satisfactory.

A system of electric lights has been installed in the dark room and other facilities arranged including several new sinks, an electric fan, etc. making it a model room for its purposes.

During the year, the bronze tablet with bas-relief portrait, honoring the memory of Charles Linden, has been placed on the wall of the Lecture Hall.

LECTURE COMMITTEE.

Mr. Howland as chairman of the Lecture Committee reported that during the year eighteen evening lectures have been delivered at which there has been a total attendance of about 3600 persons.

The names of the lecturers and their subjects are as follows:

Nov. 2, 1906. Mr. Andrew Langdon,
"The Fall of a Celestial Wanderer". Illustrated.

Nov. 19, 1906. Dr. Carlos E. Cummings,
"Jamaica". Illustrated.

Nov. 23, 1906. Prof. P. F. Piper and Richard F. Morgan,
"Cobalt and Vicinity". Illustrated.

Dec. 14, 1906. Dr. Alice Bennett,
"Every Day Life in China". Illustrated.

Jan. 11, 1907. Mr. Warren S. Johnson, Milwaukee, Wis.,
"The Air We Breathe".

Jan. 18, 1907. Dr. Albert T. Clay, Univ. of Penn., Phila., Pa.,
"Babylonia In The Time of Abraham". Illustrated.

Jan. 23, 1907. Mr. George Wharton James,
"The Mysterious Salton Sea". Illustrated.

Jan. 25, 1907. Dr. E. P. Felt, Albany,
"Destructive Leaf-feeding Insects and Their Control".
Illustrated.

Feb. 2, 1907. Rev. Peter C. Goldsmith, Salem, Mass.
"A Visit to Some Mexican Aborigines". Illustrated.

Feb. 8, 1907. Dr. Carlos E. Cummings,
"Mexico". Illustrated.

March 8, 1907. Dr. Carlos E. Cummings,
"Old Mexico, To the South". Illustrated.

March 15, 1907. Mr. Frank A. Converse,
"City Milk Supply". Illustrated.

March 22, 1907. Mr. N. W. Shed,
"By-Product Coke and the Prevention of Smoke in Large Cities". Illustrated.

April 5, 1907. Hon. James S. Whipple,
"Protection for Forests, Fish & Game".

Mr. A. Knechtel,
"The Forests of New York State". Illustrated.

April 12, 1907. Dr. Carlos E. Cummings,
"North to El Paso. Old Mexico". Illustrated.

April 19, 1907. Special.
Prof. Herman C. De Groat,
"Around the Circle in Colorado, 1000 Miles Through
The Rockies". Illustrated.

May 3, 1907. Rev. Charles Warren Currier,
"A Tour in Spain". Illustrated.

LIBRARIAN.

The Librarian, Mr. Philip S. Smith, reported that since his last report and since the date of the inventory the following accessions have been made to the Library.

Bound Volumes	37
Unbound "	200
Pamphlets	55
Publications received in exchange for our bulletins	1932
Donations from the President	89
" " Miss Letson	17

He called attention to the crowded condition of the library, compelling the storing of all foreign accessions and of early volumes of American journals in order to make room for more recent numbers. Of the 500 unbound volumes he recommended that the 350 American publications be bound and that for the present the foreign publications be stored.

A subject index is being made which when completed will greatly enhance the working value of the Library.

VOLUME VIII No. 6

BULLETIN

of the

BUFFALO SOCIETY OF NATURAL SCIENCES

ORG'D DEC. 5, 1861.

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BUFFALO, NEW YORK
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